MARIA S. MERIAN-Berichte

Subpolar gyre variability

Cruise No. MSM54

May 12 – June 04, 2016
St. John's (Canada) – Reykjavik (Iceland)

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1 Summary

(J. Karstensen)

The core working program of the Maria S. Merian expedition MSM54 was dedicated to the re-deployment of moored instrumentation and the acquisition of data from the water column in the Labrador and Irminger Sea regions. Moored instrumentation, programed for high temporal resolution sampling (<1 hour) and installed at distinct locations in the Labrador and Irminger Seas, determine the local evolution of physical properties (temperature, salinity, density, currents). Continuous installations of such system over many years provide the observational base for the analysis of systematic dynamical and hydrographic variability and eventually long term changes of the interior ocean. In a global context only a few of such long lasting ocean-reference-stations exists. Along selected sections the hydrographic (temperature, salinity, density), oxygen, and currents structure was determined using data from CTD/O_2/(l)ADCP systems. These systems operate over the full water depth, from the surface to the ocean bottom. Moreover, quasi-continuous underway data collection was performed using the Thermosalinograph (Temperature, Salinity), and surface meteorological observations, but also ship mounted ADCP systems (currents in upper 500 to 1000m).

The cruise contributed to the investigations that are done in the national RACE program, and in the international NACLIM (EU) and AtlantOS (EU) projects, and the OSNAP and VITALS initiatives.

Zusammenfassung

Das Kern-Arbeitsprogramm der Maria S. Merian MSM54 Expedition widmete sich der Wiederauslegung von Verankerungen sowie der Vermessung der Wassersäule in der Labrador und Irminger See. Mit den verankerten Instrumenten werden in diskreten Tiefen Daten aufgezeichnet aus denen Zeitserien von Temperatur, Salzgehalt, und Strömungen abgeleitet werden. Die Installation solcher Systeme über viele Jahre liefert die Basis für die Analyse der dynamischen und hydrographischen Variabilität einer Region und kann eventuell existierende langfristige Veränderungen aufzeigen. Weltweit existieren nur wenige solcher Langzeitbeobachtungsstationen. Entlang ausgewählter Routen in der Labrador und Irminger See wurde die Verteilung von Temperatur, Salzgehalt, Dichte, dem Sauerstoffgehalt und den Strömungen mittels eines CTD/O_2/(l)ADCP-Systems von der Oberfläche bis zum Meeresboden abgeleitet. Oberflächennah wurde quasi-kontinuierlich Temperatur und Salzgehalt mit dem Thermosalinographen gemessen. Auch wurden meteorologische Parameter gemessen. Die im Schiffsrumpf installierten ADCP-Systeme erlaubten es die Strömungen in den oberen 500 bzw. 1000 m durchgängig zu vermessen.

Die Reise wurde zur Datenaufzeichnung für Untersuchungen im nationalen RACE-Programm, in den internationalen Projekten NACLIM (EU) und AtlantOS (EU) und im Zusammenhang mit den OSNAP und VITALS Initiativen, durchgeführt.

2 Participants

Name	Discipline	Institution
Dr Johannes Karstensen	Chief scientist	GEOMAR
Christian Begler	Mooring, telemetry	GEOMAR
Wiebke Martens	Instruments	GEOMAR
Uwe Papenburg	Mooring, Logistics	GEOMAR
Gerd Niehus	Mooring, Logistics	GEOMAR
Amelie Klein	Blog Coordination, CTD watch	CAU Kiel
Dr Marilena Oltmanns	Mooring data, CTD watch lead	GEOMAR
Henrike Schmidt	ADCP processing, CTD watch lead	CAU Kiel
Nora Fried	CTD processing, CTD watch lead	CAU Kiel
Patricia Handmann	lADCP processing, CTD watch	CAU Kiel
Arne Bendinger	Underway data, Helper mooring, CTD watch	CAU Kiel
Jonathan Wiskandt	Helper mooring, CTD watch	CAU Kiel
Mareike Körner	Salinometer, CTD watch	CAU Kiel
Christina Schmidt	Helper mooring + protocol, CTD watch	CAU Kiel
Sijia Zou	Salinometer, RT data, CTD watch	Duke University
Greg Siddall	Mooring Seacycler	Dalhousie
Jeremy Lai	Mooring Seacycler	Dalhousie
Mike Vining	Mooring Seacycler	Dalhousie
Dr Dariia Atamanchuk	Bio-Optics, Chemistry	Dalhousie
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3 Research Program

(J. Karstensen)

The North Atlantic Ocean is one of the most important drivers of the global ocean circulation and its low frequency variability beyond inter-annual time scales. Global climate variability is to a large extent triggered by changes in the North Atlantic sea surface state.

The climate of Europe is strongly influenced by the North Atlantic Ocean circulation; in particular the eastward transport of warm water in the North Atlantic Current has a strong impact on the mild climate in Northern Europe. It connects the warm, subtropical gyre with the cold, subpolar gyre and is, in part, driven by the sinking of dense water in the northern North Atlantic.

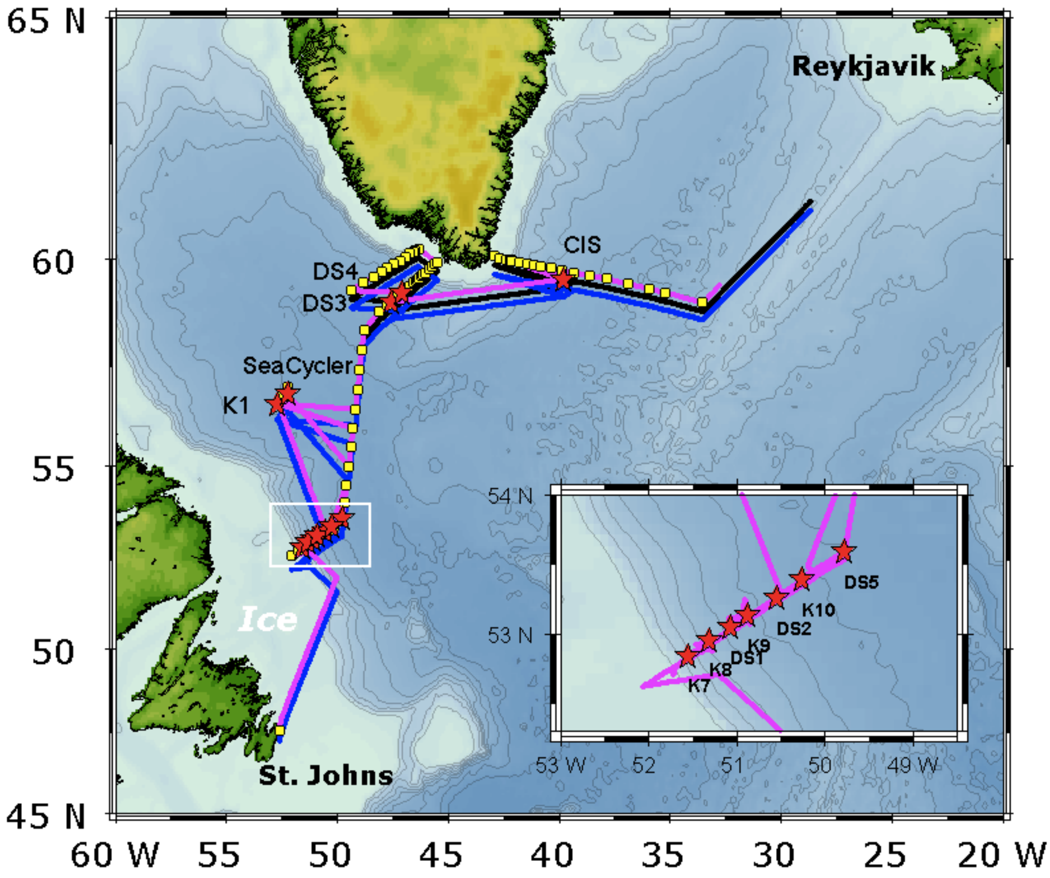


Fig. 3.1 RV Maria S. Merian MSM54 cruise track from St. Johns to Reykjavik. Yellow dots indicate CTD/lADCP casts, red stars indicate mooring operations (mooring names), 75kHz ADCP (blue), 38kHz ADCP (magenta) and underway data (black) tracks are shown with latitude offset.

Intense cooling in the Labrador and Nordic Seas in winter results in the densification and sinking of surface water (buoyancy driven overturning). At depth, the water masses spread preferentially southward. The spreading is concentrated in intense currents that stream along the western boundary in so called "Deep Western Boundary Currents" (DWBC). Beside the deep water formed in the subpolar gyre, the DWBC transport water from the overflow regions southward. Thus, variability in the strength and characteristics of the DWBC reflect the integrated effect of changes in the different formation regions of the water masses. As such, it is critical to survey the DWBC regularly and over long periods of time and to create continuous time series of the flow and its properties to be able to decompose the variability of the DWBC on its different time scales. The scientific program from the RV MARIA S. MERIAN MSM54 expedition aims to improve our understanding of the intensity of the water mass transformation and the southward transport in the DWBC.

4 Narrative of the Cruise

(J. Karstensen)

The cruise MSM54 on Maria S Merian started on the 12th May 2016, when the ship left the Pier 16 in St. Johns at 08:00 for bunkering. At 09:00 a safety briefing was done followed by an introduction to the ship. A full safety drill was done at 15:00 in St. Johns harbour basin, and at 16:00 LT we left St. Johns heading towards "Station 27", one of the longest existing marine time series stations in the world. At "Station 27" the first CTD cast was done, as a contribution to this unique time series. The test CTD station went well - all sensors on the CTD, the lADCP, and a variety of optical sensors as well as the rosette sampler operated well. Unfortunately the Underwater Vision Profiler (UVP) that we planned for using during the cruise had a small crack on one of the light bulbs and could not be used during this cruise.

From "Station 27" we headed towards the "53°N-Array", an array of 7 moorings at the southern side/exit of the Labrador Sea. We had a strong head wind and low visibility and ice-charts showed some coverage in the area of the array making navigation difficult, and the ship had to slow down a bit. We steamed the whole of the 13th May – on board preparations for the upcoming work were done. Upon arrival at the southern most mooring site of the "53°N-array" (mooring K7) the weather/sea state conditions did not allow to recover the mooring and a CTD section was started instead. The section followed the OSNAP West grid set by the UK JC32 mission, done in summer 2014. The first station was done on the shelf in 350m deep waters and with some ice around the ship. During the 2nd station further away from the shelf at 500m the CTD had a malfunction, possibly due to a shortage on one of the connectors. It turned out that the CTD device had a problem and the complete system needed to be changed (profile #4 was the first with the replaced CTD system).

Unfortunately swell and wind where from different directions and made it difficult to find a heading that prevent strong rolling and thus tension on the CTD wire. As a consequence the CTD was operated relative slow (sometimes with 0.3m/s only) and casts took long. Because of the CTD operations and the ice situation, we decided to change the sequence of mooring recovery, starting with K9 instead of K7. With the wind getting calmer the visibility was getting worst but the K9 recovery went well. It took some time before we spotted the mooring drifting at the surface, also because the Argos transmitter on the top element of the mooring did not work. We navigated under low visibility conditions (fog) to the mooring, guided by the two acoustic releases (ranging only). The CCGS Hudson was emailing us that they will operate on the shelf side of the 53°N-Array tomorrow.

At night a number of CTD cast were performed and completing an lADCP and CTD section along the 53°N-Array. At 09:00 on 16th May the second mooring was recovered (DSOW5), the most northerly one of the 53°N-Array. At this time the visibility was even worst than the day before, but the Argos transmitter worked well and supported our ranging via the acoustic releases. Next the DSOW2, a mooring equipped with a McLane profiler and an ADCP, was recovered without any problems. DSOW1 followed, a short mooring that was recovered quickly. Over night more CTD stations along the 53°N section were done and which were centred between stations of the 1st occupation. The deployment of DSOW1 and K9 on the 17th May went well, without major problems – weather and sea state were supportive. During the night of the 17th to 18th we were in close proximity to the south-eastern most part of the line (K7) and thus close to where the BIO Canadians shelf array C is located. At about 01:00 am a phone call from CCGS Hudson came in and the Igor Yashayaev (BIO, Canada) kindly informed us about their activities. It snowed about 15 cm during the time of the call. Making best use of the calm weather we recovered and deployed K7 and K8 on one single day. A 2000 m CTD calibration cast and release test (preparation for SeaCycler and BIO deployments) was done in the following night and we steamed 60 nm towards the K10 site. In the morning at 7:00am we started to communicate with K10 acoustic release, but we did not get any response. After about 1.5 hours we decided to send the release command and luckily a short time after the first element was spotted drifting at the surface. The recovery went well and we steamed to the DSOW5 position to re-install this mooring in the afternoon. In the meantime, a releaser-test shallow CTD was done.

After finishing the work at the 53°N-Array we headed towards the central Labrador Sea/K1 area. On May 21th, the K1 mooring was recovered. This mooring carried originally a surface telemetry buoy but that had stopped transmitting data in March 2015 and was later detached but recovered by chance from a Canadian coast guard ship. Marks on the wire suggested that a ship propeller could have detached the wire.

We did three CTD stations over the night and on the 22th May the deployment of the SeaCycler started. The SeaCycler, an underwater winch system, was deployed last year (2015) from Maria S Merian but shortly after the deployment the system failed because of a broken wire. The deployment preparations on deck started at 07:00. The first piece that went into the water at 08:30 was the "Mechanism float", then the "Communication float" and the "Instrument float" followed. The operations all went well and weather/sea state were very fortunate. The rest of the mooring (>3500m) where deployed as a normal mooring. The anchor was launch at 11:50 and we observed the slow falling (3 parachutes were attached) until the communication float submerged at 12:30. The first profile was received, as expected, at 18:00, indicating that the system was running.

Later that day we deployed K1. The mooring had a surface telemetry buoy installed (NACLIM project) but with a new design for air-pressure observations (using a Keller pressure sensor that can withstand up to 60 dbar pressure). During the operations, the hydraulic hose on the port side of the A-Frame broke. Moreover, it turned out after inspection that the bearing of one of the arms of the A-frame was corrupt and needed to be replaced. Knowing that the replacement would take about 1 week in the harbour, it was agreed between ship, Leitstelle, and the chiefscientists of MSM54 & MSM55, that the two cruises would be shortened. According to this new plan, the ship was scheduled to arrive in Reykjavik already on June 4th under the condition that the core scientific program of MSM54 was successfully completed by then. This was only possible because the weather had been very fortunately for most mooring operations – a situation that cannot be taken for granted.

We left the K1 area after a final CTD at the SeaCycler location (with carbon system parameter sampling) and continued with the OSNAP West CTD section. On May 23rd the telemetry messages from the newly installed K1 telemetry buoy stopped and we decided to return back to the mooring site to exchange the telemetry system on the 24th May. It turned out that one compartment of the surface buoy was not properly sealed and water flooded some electronics. The exchange buoy worked well but had no surface pressure sensor. After returning back to the OSNAP west section the CTD program was continued and we headed northward, towards the Greenland coast.

As the weather was getting very windy, we could not recover the DSOW3 and DSOW4 moorings, off the Westgreenland coast. Therefore a second CTD section was planned, a bit north of the OSNAP West section. On May 27th we headed towards that new section and came across two ships: one was the largest Viking ship build in modern times, the "Draken Harald Hårfagre", the other one was a fish trawler used by the Draken as a base ship. We learned that the Draken was out to sail from Norway to America – it was a 8 to 9 Bft wind and quite some waves but the Viking ship was doing a good job in the rough seas. The parallel section connected to the AR7W occupied a few weeks ago by CCGS Hudson. The forecast suggested that the weather would allow to recover the two DSOW moorings the next day (May 29th) .

After the recovery of DSOW3 and DSOW4, which went smoothly, we headed towards the Irminger Sea and recovered and deployed the CIS mooring on May 30th. However, we observed that the mooring was deployed in too shallow waters and one element that should have been in 40m depth visible close at the surface. Different strategies were discussed on what to do: (1) Recovery of mooring and redeployment – very time consuming and risk of severely entangled wire. (2) Lifting the complete mooring from the ground and exchanging one wire with a shorter one – under the risk that the mooring wire would break, in particular as the anchor had potentially immersed into soft seafloor. We decided to go for option (2) first and, if it failed, we would recover (option 1). At night, CTD stations were done, and on May 31st the recovery of the top 100 m (below top subsurface buoy) of CIS began. The whole operation was successful and took about 1.5 hours.

Then, we departed from the CIS area and moved westward, starting an occupation of the OSNAP East section off Greenland in the early evening. The CTD program continued until the afternoon of June 2nd and a coarse grid section through the Irminger Sea, until the Reykjanes Ridge, could be completed. During the 36 h of steaming towards Reykjavik science meetings on cruise observations (also in preparation for the cruise report) were done as well as the normal packing procedures. The weather was foggy, windy and wavy. On June 4th at 09:00 am the Merian was moored at Reykjavik port in sunny and calm weather. Cleaning of labs, custom clearance businesses followed. The MSM54 cruise was finished about 4 days ahead of the original schedule but the core program had been completed and the Maria S Merian's A-Frame could be repaired.

5 Preliminary Results

5.1 CTD observations

(N. Fried, A. Bendinger)

Throughout RV MARIA S. MERIAN MSM54 we did 87 CTD casts, which were separated into three sections: the OSNAP West station, a short section north of OSNAP West, across the DWBC at the west Greenland coast, and the western part of the OSNAP East section, approximately until the Reykjanes Ridge. The CTD #1 cast was made at the Canadian time series station "Station 27", contributing to a hydrographic time-series beginning in 1947.

A summary of CTD systems is given in table 5.1. After cast #3 the CTD-unit was changed from GEOMR SBE No. 3 to GEOMAR SBE No. 4 becuase of electronics problems (the reason could not be analysed during the cruise). The water collection with the Niskin bottles worked out almost every time. At cast #9 bottle 6 did not close and at cast #10 bottle 1 remained open although fired. During cast #24 the pump did not continuously work and we had problems in communicating with the SBE-carousel. As a consequence oxygen and pressure measurements were degraded and the cast was cancelled. During cast #29 we had problems with the oxygen at channel 1. In cast #29 pump 1 was changed and in cast #30 the second pump changed including the pump wire. At cast #33 all CON-files were changed because of a fluorometer. At cast #67 an oxygen offset occurred of more than -6%. During cast #71 there were spikes in the fluorometer in the upper 600 meters (and the lADCP failed). At cast #76 the altimeter did not work properly and the cable was changed).

Twelve CTD casts were also used for MicroCat-calibration (#8, #9, #11, #17, #24, #25, #26, #27, #33, #38, #46, #68) and releaser tests (#9, #10, #68). The calibration procedure included 5 stops at different depths for 5 minutes each during the CTD upcast. A number of CTD-casts were done close to the moorings positions as reference casts. Bottle samples for salinity and oxygen were used for CTD sensor calibrations (see calibration section for details).

Tab. 5.1: CTD system configuration overview during MSM54. Note the CTD unit was changed from GEOMAR SBE#3 to GEOMAR SBE#4. TM: Transmissionsmeter, PAR Sensor (2000m) from Maria S Merian CTD.

Cast	SBE-9 CTD	SBE-5T Pump	T_1 T_2	C_1 C_2	V_0 V_1	V_2 V_3	V_4 V_5	V_6 V_7	SBE-32	SBE-11 DU
1-3	SBE-3	4375 5007	5807 4835	3425 3959	Oxy-0145 Oxy-2590	Alti-42299 PAR-4716	FLNTURB 2294	TM-1617 CDOM 2687	951 SB-8	0674 DU-4
4 - 28	SBE-4	5051 2826	4833 4875	2443 3366	Oxy-1287 Oxy-1739	Alti-42299 PAR-4716	FLNTURB 2294	TM-1617 CDOM 2687	951 SB-8	0674 DU-4
29	SBE-4	4375 2826	4833 4875	2443 3366	Oxy-1287 Oxy-1739	Alti-42299 PAR-4716	FLNTURB 2294	TM-1617 CDOM 2687	951 SB-8	0674 DU-4
30 - 87	SBE-4	4375 5007	4833 4875	2443 3366	Oxy-1287 Oxy-1739	Alti-42299 PAR-4716	FLNTURB 2294	TM-1617 CDOM 2687	951 SB-8	0674 DU-4

Summary of CTD calibration settings

CTD-Setup # used in profiles 1:3, C-misfit (PSS78 equivalent): 0.004

O-misfit: 1 µmol/kg , Deck offset applied to data: 1.36 dbar

CTD-Setup # used in profiles 4:87, C-misfit (PSS78 equivalent): 0.001

O-misfit: 1 µmol/kg, Deck offset applied to data: 0.19 dbar

5.1.1 CTD Sections

An overview of the OSNAP West and (partly) East sections for temperature, oxygen, salinity and currents (lADCP) is shown in Figure 5.1. In the Labrador Sea we surveyed by chance in very intense mesoscale eddy that is clearly visible in all sections. The homogenous water in the eastern part of the section, in the Irminger Sea, is presumably created by a combination of recently formed Labrador Sea Water and local convection in the Irminger Sea.

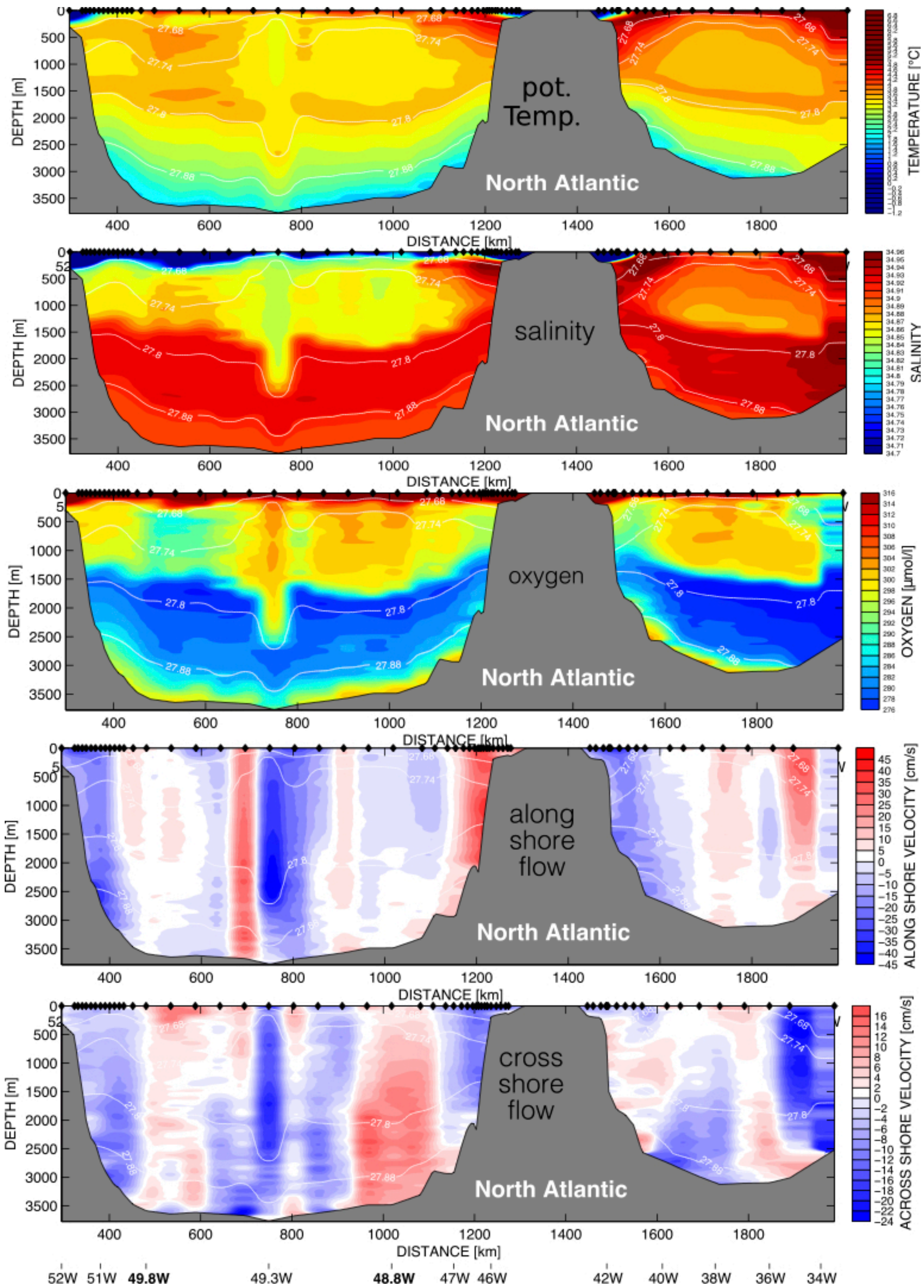


Fig. 5.1: CTD transect along 53N array. Included are OSNAP CTD stations #12-#23 with #12 lying closest to the Canadian coast. Shown are potential density (top panel), potential temperature (mid) and salinity (bottom). Note that contour levels are not equally spaced.

5.2 Mooring Operations

(M. Oltmanns, C. Schmidt, G. Siddal, J. Wiskandt, J. Karstensen)

One goal of the cruise was to service moorings: The "53°N-Array" moorings (seven) and two moorings in the WHOI array at the entrance of the Labrador Sea, and the "convection center moorings" in the central Labrador and Irminger Sea (K1, SeaCycler, and CIS, respectively). These purpose of having the moorings installed is to observe the variability of the DWBC, the convection activity in the Labrador and Irminger Seas, and transport and property changes of the dense overflow waters. In total we recovered 11 moorings and deployed 12 (table 5.2). Details about recovered moorings can be found in the Appendix.

Tab. 5.2: Mooring recovery & deployment overview

R*	D**	Mooring		Date and Time	Latitude	Longitude	Depth	Watchdog/ Argos ID/ IMEI	Number of Instruments
x		CIS 13	KPO 1042	30.05.2016 11:55-14:03	59°31.827'N	039°47.029'W	2928	2269	19
	x	CIS 14	KPO 1167	30.05.2016 18:14-20:39	59°31.77'N	039°46.78'W	2908	30003401 3904340	21
x		DSOW 1	KPO 1113	16.05.2016 21:22-21:30	53°02.764'N	051°04.801'W	2620	none	4
	x	DSOW 1	KPO 1159	17.05.2016 11:06-12:15	53°2.796'N	051°4.804'W	2599	15172	7
x		DSOW 2	KPO 1115	16.05.2016 16:45-18:38	53°15.497'N	050°32.755'W	3179	7848	7
	x	DSOW 2	KPO 1161	20.05.2016 17:00-19:07	53°15.399'N	050°33.267'W	3162	12264	10
x		DSOW 3	KPO 1122	29.05.2016 15:17-15:36	59°0.46'N	47°33.87'W	3104	none	4
	x	DSOW 3	KPO 1164	29.05.2016 15:58-16:29	59°0.43'N	047°33.87'W	3106	30003401 3902340	4
x		DSOW 4	KPO 1123	29.05.2016 10:55-11:18	59°12.930'N	047°4.910'W	2941	none	4
	x	DSOW 4	KPO 1165	29.05.2016 11:45-12:23	59°13.03'N	047°5.03'W	2942	12620	4
x		DSOW 5	KPO 1133	16.05.2016 12:39-12:59	53°35.510'N	049°46.889'W	3615	11458	4
	x	DSOW 5	KPO 1163	19.05.2016 17:07-17:46	53°35.65'N	049°46.84'W	3605	15173	4
x		K 1	KPO 1117	21.05.2016 17:08-19:08	56°35.448'N	052°38.244'W	3511	12621	13
	x	K 1	KPO 1166	22.05.2016 17:13-21:11*	56°33.702'N	052°39.421'W	3490	7848	24
x		K 7	KPO 1111	18.05.2016 9:24-10:56	52°51.935'N	051°28.717'W	1716	XIOS 5467	12
	x	K7	KPO 1157	18.05.2016 20:49-22:25	52°50.418'N	51°32.899'W	1400	2263	16
x		K 8	KPO 1112	18.05.2016 12:42-14:08	52°56.461'N	051°18.956'W	2223	667	13
	x	K 8	KPO 1158	18.05.2016 16:33-18:35	52°57.339'N	51°18.606'W	2201	5510	17
x		K 9	KPO 1114	15.05.2016 16:51-19:22	53°07.842'N	050°52.526'W	2916	5511	14
	x	K 9	KPO 1160	17.05.2016 15:27-18:18	53°8.221'N	50°52.253'W	2901	2266	21
x		K 10	KPO 1116	19.05.2016 10:55-13:15	53°23.244'N	050°15.282'W	3381	XIOS 2268	18
	x	K10	KPO 1162	20.05.2016 10:48-13:22	53°23.245'N	050°15.285'W	3212	11307	22
	x	SeaCycler Vitals Mooring V16-5		22.05.2016 9:40-13:23	56°49.476'N	052°12.950'W			

5.2.1 Instrument performance

All 11 moorings were recovered according to plan. Overall, they were equipped with 68 microcats, 23 Aquadopps, 2 argonauts, 14 RCM-8, 3 ADCPs, a SeaGuard (loan DEVELOGIC, Hamburg) and a McLane moored profiler. Among the MicroCat SBE37s, 67 came back with full data records in at least one of the measured parameters, and only one (MC12151 from the K1 mooring) stopped recording after about 7 months due to an added oxygen sensor which resulted in an early discharge of the battery. Most MicroCat SBE37s took very accurate measurements and required only small corrections from the calibration casts. Two MicroCat SBE37s (MC2271 and MC1720, both from CIS13) had defective conductivity records and MC2271 also took wrong pressure measurements and MC1720 also had a corrupt temperature record. Two other MicroCat SBE37s (MC10689 from DSOW2 and MC10657 from K1) needed a large pressure correction, but otherwise performed well. All Aquadopps returned full records in their current measurements, but some had offsets in their pressure recordings well above 10 dbar, especially the ones at depth. Thus, pressure corrections had to be applied to the Aquadopps 26209-30 (K8), 26209-03 (DSOW3), 26209-26 (DSOW1), 26209-09 (DSOW4) and 26209-01 (DSOW4). Among the two argonauts, one came back with a full record. The other one (299 from K10) had considerable rotor stalls. Rotor stalls were also seen in several RCM-8, including RCM10500 (K1), RCM11442 (K9), RCM9726 (DSOW5) and RCM4998 (K7), and RCM9820 (CIS13) stopped working early in 2015. In addition, the pressure measurements of RCM11442, RCM9726 and RCM10501 were corrupt and had to be removed. All three ADCPs (from CIS13, K7 and DSOW2) returned full data records. The moored profiler (DSOW2) only worked sporadically.

5.2.2. Deployment of additional sensors and data telemetry systems

As a contribution to AtlantOS WP5.3, and in collaboration with Dalhousie University and Ocean Tracking Network, Canada, oxygen sensors and passive acoustic sensors (150m) were mounted on selected moorings (Figure 5.2; Appendix). The oxygen sensors where placed in the core-depth of Labrador Sea Water, in Northeast Atlantic Deep Water, and in the core of the lNADW (at K9).

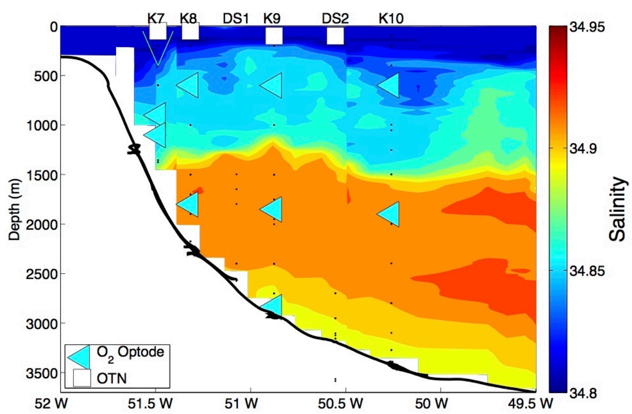


Fig. 5.2: Deployment locations of oxygen optodes (with RBR logger; triangles), and passive acoustic sensors (VEMCO VR2W; squares) at the 53°N Array. Background: salinity distribution based on cruise survey data.

A redesigned surface telemetry buoy from the company DEVELOGIC (product name: MISAT II) was installed on the K1 mooring. The MISAT II was motivated by the "Pinck Telemetry" buoy, developed by Andreas Pinck, GEOMAR during the 2000's. In collaboration with DEVELOGIC, the buoy was transformed into a commercial product. Mooring data transmission is achieved via the inductive transfer of instrument data along the mooring wire to the surface buoy. The data collected by the buoy is send to shore every 4 hours (via Iridium satellite communications service). In 2011, an effort was started to also use the surface buoy for acquisition of atmospheric observations. Air temperature and air pressure were the target parameters, which are of particular interest in deep convection regions. The first prototypes had numerous technical as well as sensing problems.

In 2014 (N/O Thalassa MSM40 cruise), we successfully deployed two of the MISAT I telemetry buoys in the central Labrador and Irminger Sea. The Irminger Sea buoy failed sending data from the beginning and in 2015 an attempt was started to redeploy the surface buoy during a cruise with the Dutch vessel PELAGIA (CS: Laura de Steur). The surface buoy was not found during the PELAGIA cruise and from the instrument records recovered during MSM54 we could confirm that the surface buoy had detached on April 7th, 2015. Although the reason for the break-off is unclear, it can be said that the mooring wire in the upper three hundred meters was entangled, suggesting an insufficient mechanism for preventing entanglement (shackles), which may lead to a break off of the wire. Very likely, the break off occurred at the transition from the buoy head to the wire, a part that is under very strong mechanical stress. The surface telemetry buoy at the K1 site in the Labrador Sea transferred data until 2016. Then the buoy stopped transmitting, again for unknown reasons. The Canadian Coast Guard later found the buoy by chance. Inspecting the wire after the K1 recovery during MSM54 very deep marks were found, maybe from a ships propeller.

Because of the loss of the surface telemetry buoy at CIS in 2015 we had only one device available during MSM54 and decided to install the telemetry system at the K1 mooring. The deployment was done May 22nd. It was a MISAT II prototype with air temperature and air pressure sensor (Keller pressure sensor that can withstand up to 60 dbar pressure). Telemetry messages came in during the deployment time (towing the mooring behind the ship) but messages stopped after the mooring had been launched and settled. So we retuned to K1 on May 23rd and replaced the telemetry system with an older system (MISAT I) without air pressure sensor. Investigating the recovered MISAT II buoy revealed that one compartment of the surface buoy was not properly sealed and water flooded some electronics. Buoy data can be downloaded at:http://gliderweb.geomar.de/html/wiki/tmp/www/index.html?/html/wiki/tmp/www/projects/k1/k1_data.html

5.2.3 SeaCycler deployment

SeaCycler is a moored, deep-ocean, surface-piercing profiler with two-way satellite communication. This means it's anchored to the sea floor and cycles (or "profiles") oceanographic sensors through the upper 150m of the ocean collecting measurements on the way. At the top of the profile, it surfaces a satellite telemetry system to transfer data to shore and receive new commands. After communication, it returns its profiling elements to a depth resistant to bio-fouling and safe from surface hazards such as ships and storm waves. Primary to

SeaCycler's success is its ability to profile a sizable sensor suite (currently 11 sensors) using substantial buoyancy to resist mooring knock-over from ocean currents while conserving battery-stored energy to permit over 500 x 150m profiles throughout year-long deployments. SeaCycler senses surface conditions and will abort profiles prematurely if wave loading exceeds an adjustable limit. Profiling movement is controlled by a unique drive system, which powers an underwater winch that has built-in compliance and no rotating seals or slip-rings to enhance reliability. The "SeaCycler mooring" contains the SeaCycler at its top, with 9 x MicroCAT CTD's and two RDI ADCP's below it.

Deployment of the system

The weather was good with light winds and 1 to 2m waves. We started early in the day as winds were forecasted to pick up. A quick site survey revealed flat bathymetry and good water depths. SeaCycler components were deployed in the usual "MechFloat-tow, CommFloat, SensorFloat, MechFloat-slip" fashion which worked well. The A-Frame was used to deploy most mooring components including the MechFloat. The CommFloat was slipped by hand and a slewing crane deployed the anchors. A capstan winch was used to pay out cable and deck cleats were used to slip mooring loads.The deployment took less time than expected and resulted in an estimated 3-hour tow to achieve station. It was decided to omit 1 x 5m length of chain and deploy immediately to avoid the long tow. The final mooring location was about 2 nm further from the AR7W line than originally planned. The ship was maneuvered to follow the mooring's top floats until they submerged. A nice gentle tow was observed. No mooring beacon hits were received after submergence. Hydro-acoustic triangulation was not performed at this time and instead, the ship was relocated for K1 deployment. The ship returned to the SeaCycler site later that evening, but triangulation was not performed since a SeaCycler surfacing had already occurred providing a more accurate GPS location fix. The 2400kg double-quad steel anchor was slipped in 3526m of water and eventually settled on the bottom 1016m to the South-East. It took 38 minutes for the top of the mooring to submerge after anchor release. This equates to a SeaCycler descent rate of 0.48 m/s, which is well within acceptable limits. New SeaCycler data is reported daily at: http://cercos.ocean.dal.ca/seacycler/home

5.2.4. Example for the acquired time series data

Some example time series of uncalibrated data from the 21-month deployment period (August 2014 to May 2016) are presented below (Figure 5.3). The 53°N Array (outflow) consists of mooring K7, K8, DSOW1, K9, DSOW2, K10, DOSW5 and our (GEOMAR) contribution to the WHOI Array west of Greenland consists of moorings DSOW3, DSOW4 (inflow).

lNADW flow in the DWBC

The flow speed and direction at the deepest depth at all mooring in the lNADW layer of the DWBC (Figure 5.3) shows the directional stability of the flow but with some speed variations that are probably related to a meandering of the DWBC and the impact of topographic waves. The new DSOW5 mooring is located in the termination of the DWBC. The flow on the northern side of the Labrador Sea (WHOI array) is northward (into the Labrador Sea) with DSOW4 well within the lNADW and DSOW3 at the edge of the DWBC.

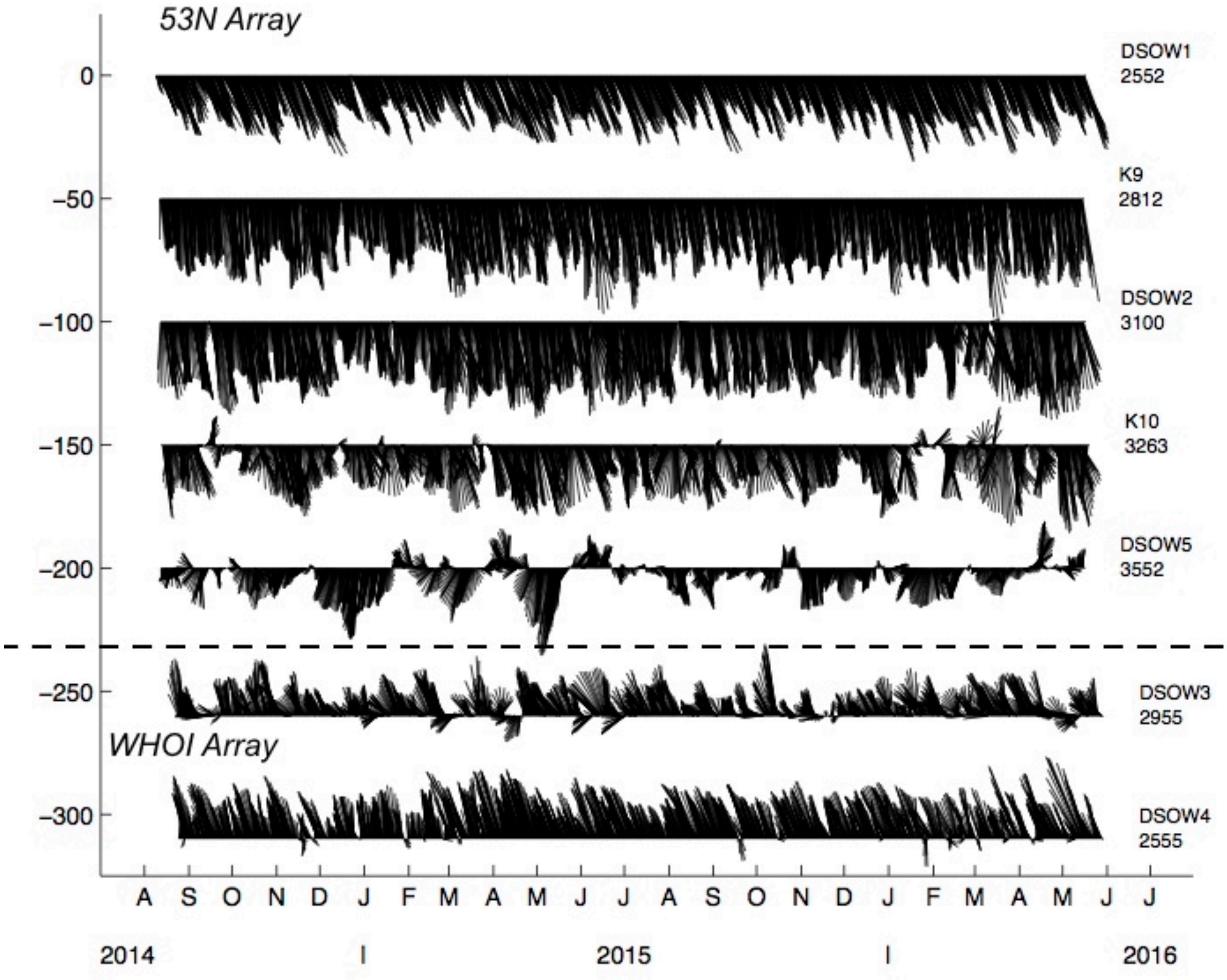


Fig. 5.3: Current vector time series from current meters placed in the lNADW part of the Deep Western Boundary Current. Upper 5 instruments are in the 53°N array, the lower two are in the WHOI array on the western side of Greenland.

Temperature time series from the Central Labrador Sea K1 mooring

Since 1997 the K1 mooring is installed in the central Labrador Sea, in the area where deepest convection in winter is expected to occur. While in recent years a general warming was observed (Figure 5.4), the winter since 2014 are characterized by deep convection that even reached below 1500m depth. The introduction of cold water to great depth stopped the warming trend and the temperatures are in 2016 are comparable with those at the beginning of the 2000s.

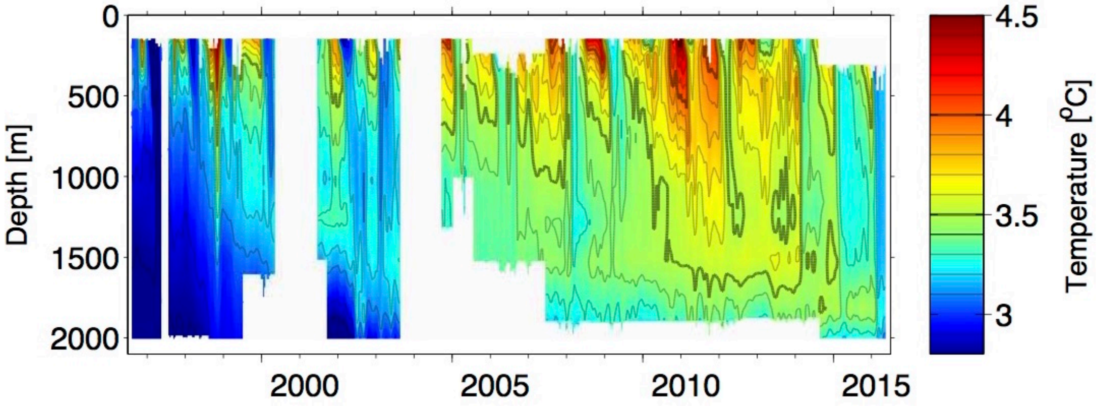


Fig. 5.4: Temperature time series of the K1 mooring from 1997 to 2016 (MSM54 recovered data from 2014 to 2016)

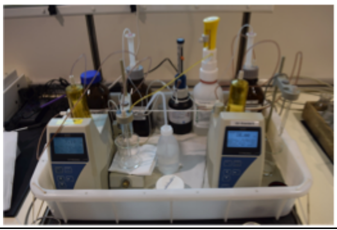
5.3 Water Sampling

(D. Atamanchuk, K. Fupsova, M. Köner, S. Zou)

5.3.1 Oxygen

In order to calibrate the oxygen sensors of the CTD rosette, water samples have been collected and titrated onboard. GEOMAR, Kiel and the CERC.OCEAN group at Dalhousie, Halifax, Canada provided two titration systems for the analysis of oxygen samples. Chemistry behind the method was described by Winkler back in 1888. The two systems utilize their own detection method (i.e. voltammetry in CERC.OCEAN system vs. colorimetry in GEOMAR), sample volume and concentration of reagents. A description of the systems and their main characteristics are provided below (table 5.3).

Tab. 5.3.: Features of the two Winkler systems onboard MSM54.

	GEOMAR 	**CERC.OCEAN** 
Titration method	manual	automated
Resolution of titrator	0.01	0.0001
Detection method	Colorimetric (blue color of I_2/starch complex)	Voltametric (reduction of I_2 to I^- on Pt electrode)
Sample volume	ca 100ml	ca 300ml
Reagents added	1ml $MnCl_2$ (6M) 1ml NaOH/NaI (3M/3M) 1 ml H_2SO_4 (50%) 0.5 ml ZnI/starch	1ml $MnCl_2$ (6M) 1ml NaOH/NaI (3M/3M) 1 ml H_2SO_4 (50%)
Titrant	0.02M $Na_2S_2O_3$	0.2M $Na_2S_2O_3$
Standard	0.01N $KH(IO_3)_2$	0.01N $KH(IO_3)_2$
Blank	V2-V1 difference	Linear regression
Input parameters for calculations	t (lab)	t (lab) t (in situ)

Samples were collected immediately after the CTD rosette was put on deck. A piece of Tygon tube was used to transfer the samples from Niskin bottles into vials. The sample vials were flushed with water 2-3 times their volume. Special care was taken to avoid bubbles in both the tube and the vials. Samples were immediately pickled with the $MnCl_2$ and NaOH/NaI reagents, the stopper was dropped in place and the vials were shaken to ensure the reactions between water sample and reagents were completed. The samples were put in the fridge and analyzed within 2-6 hours after sampling. Before analysis the samples were vigorously shaken again and precipitate was left to settle before titration commenced. Blank reagents were run whenever a new batch of reagents was prepared.

Tab. 5.4.: A summary of reagent blanks.

Date analyzed	Average blank (GEOMAR), ml	Average blank (CERC.OCEAN), ml	Difference, ml
14/05/2016	0.00	0.0032	-0.0032
26/05/2016	-0.003	0.0004	-0.0034

The difference in estimated blanks was due to the difference in methods used. Linearization method usually gives a higher blank. For the GEOMAR system the error is meaningless because it's below the resolution of the instrument. For the CERC.OCEAN system, however, the offset could result in a -0.5 µM oxygen difference when compared to GEOMAR system values (table 5.4).

Standardization of titrant was conducted every day the samples were run. Several batches of standard were prepared during the cruise. Each system used its own standard with different concentration. The data is summarized in the table 5.5. Molarity is an average calculated from 3-5 replicates.

Tab. 5.5: A summary of standardization of the titration solutions.

Date analyzed	Batch	Molarity ($Na_2S_2O_3$) *10	t (lab)
GEOMAR			
14/05/2016	1	0.1988	21.5
15/05/2016	1	0.1996	21.5
16/05/2016	1	0.1992	21.5
17/05/2016	1	0.1992	21.3
18/05/2016	2	0.2016	22.0
20/05/2016	2	0.2004	20.6
22/05/2016	2	0.2008	20.5
24/05/2016	2	0.2004	20.0
25/05/2016	2	0.2008	20.6
26/05/2016	2	0.1996	20.5
27/05/2016	2	0.1992	20.6
28/05/2016	3	0.1980	20.7
31/05/2016	3	0.1980	20.6
02/06/2016	3	0.1984	21.0
CERC.OCEAN			
14/05/2016	1	0.2005	20.5
15/05/2016	1	0.2014	21.6
16/05/2016	1	0.2019	22.0
18/05/2016	1	0.2024	21.7
22/05/2016	1	0.2031	20.5
24/05/2016	1	0.2017	20.0
25/05/2016	1	0.2017	20.3
26/05/2016	1	0.2018	20.2

27/05/2016	1	0.2023	20.2
28/05/2016	1	0.2027	20.9
31/05/2016	1	0.2016	20.5
01/06/2016	1	0.2016	20.7
02/06/2016	1	0.2017	21.2

A total of 448 samples were taken and processed on the GEOMAR titration system, of which 42 were replicates. Precision of the system was 0.62 µM (0.5 µM excluding outliers). During analysis 22 samples were flagged as "questionable quality" due to mishandling of the samples or equipment failure (table 5.6). The summary is highlighted below.

Tab. 5.6: A list of the samples processed on the GEOMAR System that were marked "questionable quality"

Date analyzed	**Station No.**	**CTD station**	**Niskin Bottle No.**	**Comments**
2016/05/14	MSM054_302-0001	2	1	questionable quality (qq)
2016/05/14	MSM054_302-0001	2	9	qq
2016/05/15	MSM054_308-0001	9	2	qq
2016/05/15	MSM054_303-0002	4	7	qq
2016/05/15	MSM054_303-0002	4	9	small bubble in the tube
2016/05/16	MSM054_311-0001	11	4	qq
2016/05/17	MSM054_318-0001	15	5	qq
2016/05/18	MSM054_323-0001	18	4	qq
2016/05/18	MSM054_319-0001	16	5	wrong stopper, questionable quality
2016/05/24	MSM054_347-0001	32	6	qq
2016/05/25	MSM054_355-0001	38	3	qq
2016/05/25	MSM054_353-0001	36	3	run out of titration solution
2016/05/26	MSM054_365-0001	48	2	qq
2016/05/26	MSM054_367-0001	50	1	qq
2016/05/27	MSM054_375-0001	58	6	forgot to write down the number
2016/05/27	MSM054_374-0001	57	1	qq
2016/05/28	MSM054_382-0001	65	3	qq
2016/05/28	MSM054_384-0001	67	6	qq
2016/05/31	MSM054_393-0001	70	1	qq
2016/05/31	MSM054_401-0001	77	2	qq
2016/06/02	MSM054_408-0001	84	2	qq
2016/06/02	MSM054_411-0001	87	5	qq

A total of 182 samples were collected and processed on the CERC.OCEAN titration system, of which 10 were replicates. Based on the replicates, precision was estimated to be of 0.69 µM (0.29 µM excluding outliers). Summary of the sampling scheme is provided in the supplement material.

5.3.1.1 Oxygen data quality and methods assessment

Data from both systems were analyzed with respect to offset between the two methods and possible sources of the errors (Figure 5.7). An offset between the two systems (CERC.OCEAN (Dal) minus GEOMAR) was -0.48 µM on average, with standard deviation of 2.16µM. Error distribution was more or less even without obvious patterns. Less variability at the middle of the sampling period might be explained by operations during calm weather, which allows for more thorough following of sampling and processing protocols.

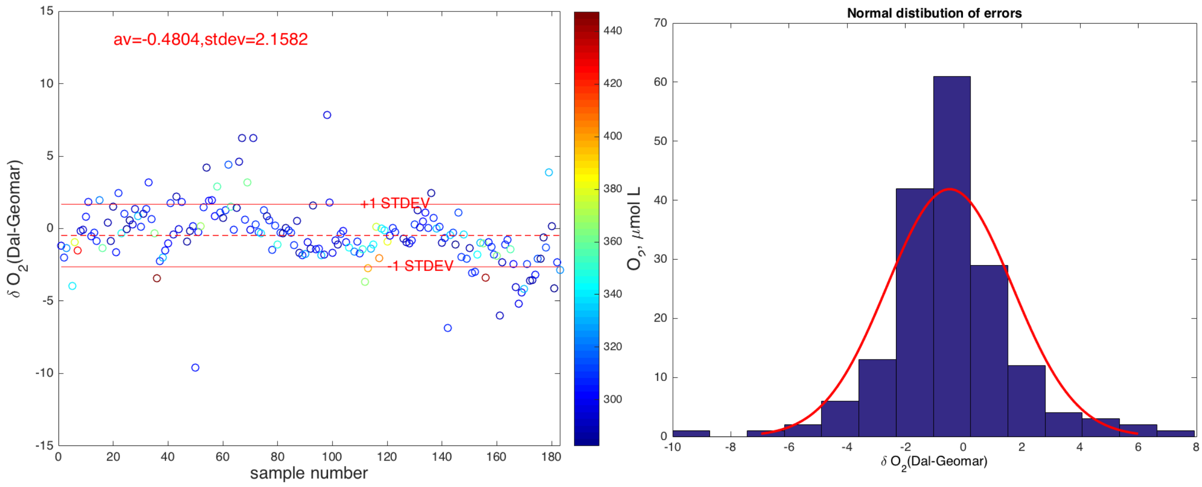


Fig. 5.7: (left) The differences in oxygen values between CERC.OCEAN (Dal) and GEOMAR systems. (right) Distribution of differences.

Likewise, neither temperature, salinity nor depth of sampling had consistent relation to with the differences between the two techniques (Figure 5.7).

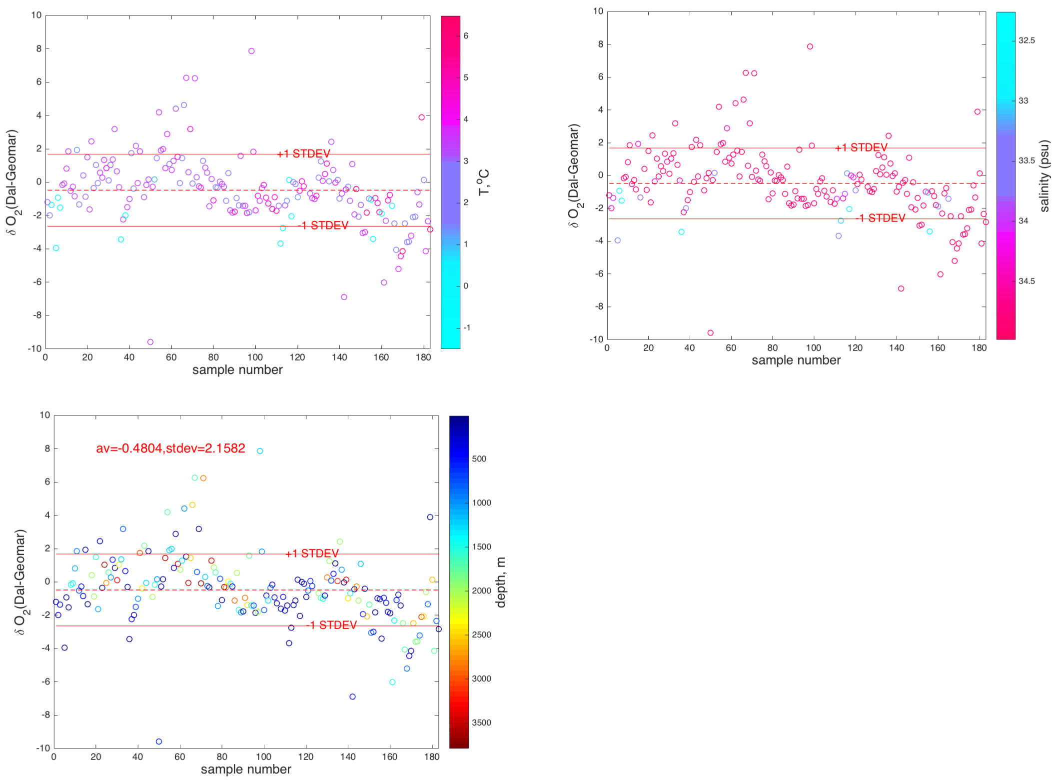


Fig. 5.7: (upper, left) Difference in relation to sample temperature, (upper, right) differences in relation to sample salinity, (lower) differences in relation to sample pressure/depth

5.3.2. Carbonate System and Nutrients

Carbonate system and nutrient samples were collected at several locations close to the deployed moorings. The main objective of taking the samples was to calibrate CO_2 instruments on the deployed moorings. The secondary goal was to get a (more or less) decent representation of the status of the carbonate system parameters and nutrients along the OSNAP-West line.

Two 250ml blue cap bottles were filled from each Niskin bottle for the carbonate system analysis. The bottles were flushed with 2-3 volumes of water prior to sampling. Samples were poisoned with 0.1 ml of saturated $HgCl_2$ solution immediately after filling and then sealed. The samples were stored in plastic containers on deck. The samples will be analyzed for Total Alkanility, pH and Total Inorganic Carbon at the CERC.OCEAN facilities shortly after the cruise's completion.

Nutrient samples were first collected in 60ml syringes and then filtered into two 15ml vials shortly after for transportation and storage. The samples were filtered through pre-combusted GF/F filters with pore sizes of 0.7 microns. After securing the caps, samples were placed in a -18C freezer and transported in dry-shippers back to the CERC.OCEAN lab. Analysis of these samples will be conducted on the San++ Continuous Flow Analyzer from Skalar, Canada.The list of samples is provided in the supplementary material.

5.3.3. Chlorophyll and CDOM

Chlorophyll and CDOM samples were collected for calibration of the sensors and instruments mounted on the CTD rosette and on SeaCycler Mooring. Chlorophyll samples were collected in the upper 200m of the water column in a couple of areas, while CDOM samples were taken at the location of the deployed SeaCycler mooring.

For Chlorophyll, approximately 2L of seawater were collected directly from each Niskin bottle and transferred into plastic, opaque Nalgene bottles. These samples were kept chilled until filtered. Three replicates from each sampling depth were filtered in darkness onto 0.7 micron GF/F 25 mm filters. Color indication on the filters were used to determine the volume needed. The sample filters were flash-frozen using liquid nitrogen, placed in Petri dishes, and stored in dry shippers at -70 °C.

For CDOM approximately 1L was collected directly from each Niskin bottle into plastic, opaque Nalgene bottles. These samples were kept chilled until filtered using 0.2 micron nucleopore membrane filters. The filtrate was stored in 250ml blue cap bottles in a dark and cool environment on the deck of the vessel.

5.3.4. Salinometer

On board were two GEOMAR instruments Guildline Autosal salinometer, #4 (Model 8400B, AS4) and Guildline Autosal salinometer, #8 (Model 8400B, AS8). Throughout the cruise only the Guildline Autosal salinometer #8 was used.

The measurement principle of the Autosal is based on determining the electrical conductivity of a salinity sample in relation to a reference conductivity. The conductivity ratio is then converted to salinity. The conductivity measurement range of the salinometer is between 2 and 42 and the accuracy is according to the manufacturer better than ±0.002.

At 85 of the 87 CTD stations salinity samples were collected at various depth. Moreover, salinity samples from the Thermosalinograph system were taken approximately twice a day (compare section 5.5). Before determining the salinity with the salinometer, the water samples had been stored in the laboratory for at least 24 hours to equilibrate to room temperature. According to the salinity substandard temporal evolution (Figure 5.8) the salinometer worked very stable throughout the cruise.

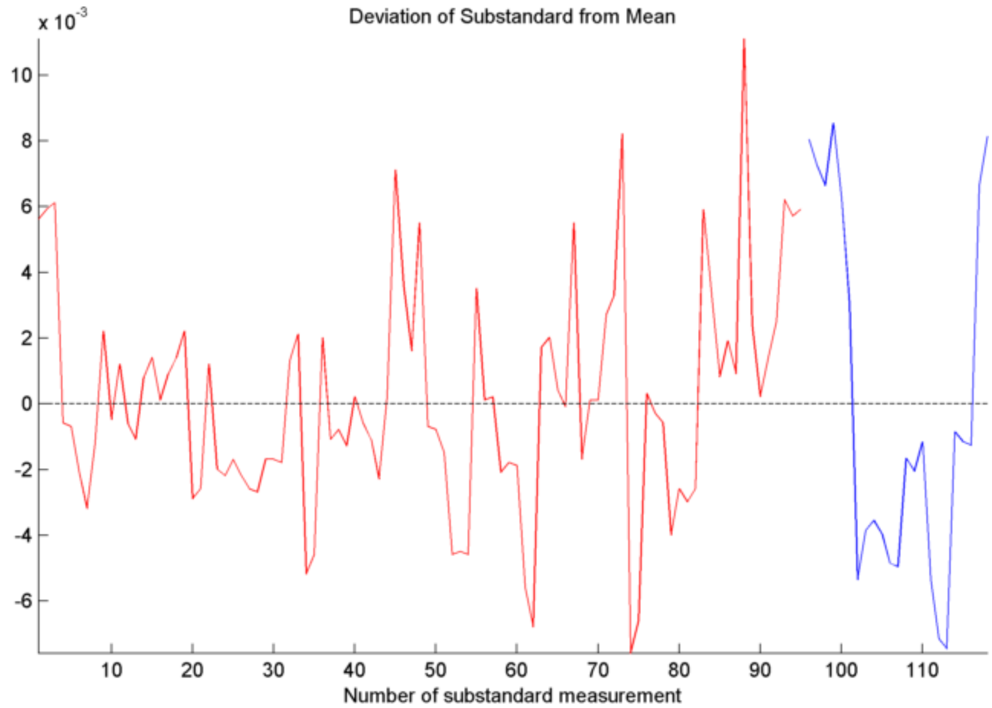


Fig. 5.8: Variability of the substandard samples (1st batch red, 2nd batch blue)

The bath temperature of AS8 was constant throughout the cruise with 24°C in a temperate room of 23°C. A standardisation of the instrument was performed at the beginning on 14th May using IAPSO standard seawater (batch: P156, K15: 0.99984) with a respective salinity of 34.9937. That value was set by adjusting a resistance to get the required conductivity measurement (potentiometer). Successive standard measurements with IAPSO standard seawater also indicated stable behaviour of the instrument.

5.4 Acoustic Doppler Current Profiler data

5.4.1 Lowered ADCP

(P. Handmann, H. Schmidt)

During MSM54 two workhorse 300 kHz ADCPs were mounted on the CTD rosette and used for LADCP measurements. In total 87 profiles were acquired. Starting from profile #1 we installed SN #6268 as down-looking and SN #11436 as up-looking instrument (both GEOMAR instruments), running them in a master-slave configuration "with 2 second periodicity and interleaved pinging". Because the SN #11436 stopped collecting data at profile #42 it was replaced by the Instrument SN #1973.

Data processing was done with the GEOMAR LADCP processing software V10.12, which includes both shear and inversion methods to derive an absolute velocity profile. CTD data files (including navigational data and synchronized time) and the shipboard ADCP (both 75kHz an 38 kHz) data were used. Some irregularities that occurred during the operations are listed in table 5.7. First results are shown in Figure 5.1, along with the hydrographic data, and which nicely depicts the in- and outflowing Deep Western Boundary Current.

Tab. 5.7: Summary table of specific profiles

CTD #	Comment
003	Abort due to sensor problems with CTD
024	Abort due to sensor problems with CTD
042	Master stopped working due to technical difficulties, only DN42000 available
043	New Master installed SN:1973
071	Profile recorded until 1000 m upcast due to empty battery

5.4.2 Ship mounted ADCP

(H. Schmidt, P. Handmann)

Instrument setup and configuration

During MSM 54_1 the two vessel mounted ADCPs, both RDI Ocean Surveyors, operating at frequencies of 38 kHz and 75 kHz, respectively, were used. The 38 kHz instrument is installed in the midships shaft and usually provides good quality velocity measurements within a depth range of about 40 to 1400 m. The 75 kHz instrument is installed in the ship's hull mount towards the bow of the ship, 6 m below water level, and usually provides a useful depth range of about 10 to 700 m. This units worked faultlessly throughout the cruise, starting on 112th May, 20:13 (UTC), and ending on 3rd June, 12:48 (UTC), shortly before leaving St. John's and arriving in Reykjavik and provided data of good quality during that period, except for short periods when they were stopped or interfered, caused by the need to use other acoustic instrumentation for certain operations, e.g. mooring recoveries and deployments or releaser tests (see table 5.8).

Tab. 5.8: Operating time of the two vessel mounted ADCPs

Date	Time (UTC)	ADCP Status	Comments
12.05.2016	20:13	on	Start measuring after 1st CTD
15.05.2016	15:45	off	Mooring recovery (K9)
15.05.2016	21:12	on	Finished recovery
16.05.2016	11:15	off	Mooring recovery (DSOW5)
16.05.2016	12:51	on	Finished recovery
16.05.2016	15:51	off	Mooring recovery (DSOW2)
16.05.2016	19:04	on	Finished recovery
16.05.2016	20:28	off	Mooring recovery (DSOW1)
16.05.2016	22:02	on	Finished recovery
18.05.2016	11:52	off	Mooring recovery (K8)
18.05.2016	15:31	on	Finished recovery
19.05.2016	15:55	off	Releaser test
19.05.2016	16:09	on	End releaser test
03.06.2016	12:48	off	End measuring (reaching EEZ)

The ADCPs were controlled from a dedicated PC using the software VmDas, version 1.46, to send the startup commands to the deck unit and save the data received from it. The setup used for the 75 kHz ADCP was: pinging as fast as possible in narrowband mode, with 60 bins of 16 m each, and a 8 m blanking distance between transmit and receive. This configuration gives a maximum depth range of 800 m, but in practice the data quality degrades quickly below about 650 m. On 25th May the setup of the 75 kHz ADCP was changed to: pinging as fast as possible in narrowband mode, with 60 bins of 8 m each. The misalignment angle of 45° is an approximate value. The correct angle will be determined during data processing. The setup for the 38 kHz ADCP during the entire cruise was: pinging as fast as possible in narrowband mode, with 16 bins of 32 m each, and a 16 m blanking distance between transmit and receive. This configuration gives a maximum depth range of 1500 m, but also here too, the data quality degrades quickly below about 1300 m.

Navigational data

Navigational data was broadcast from the ship's systems to the ADCP PC, collected using VmDas and integrated into the ADCP dataset. The primary source was the Kongsberg Seapath 200 GPS, which has an accuracy of 0.7-1.5 m for position, 0.075° for true heading and 0.03° for both pitch and roll. As a backup, positional data from a Trimble SPS461 DGPS was also collected.

Data quality and interference with other acoustics

As an intermediate step between data collection and processing, data quality was regularly controlled using the WinADCP software, version 1.14, to check echo intensity and correlation levels for signs of signal degradation or interference from other acoustic systems on board. The 12kHz echo sounder EM122 was in use during the whole cruise and delivered high quality bathymetry data without noticeable interference. There was also no noticeable interference with the acoustics during the releaser tests or mooring recovery.

Further processing and preliminary results

The ADCP data was split into chunks of a couple of hours up to 2 days long, backed up to the main data server and processed using OSSI, a Matlab toolbox developed at GEOMAR, Kiel. The navigational data integrated by VmDas in the ENX files was used, and 1 minute average velocities calculated for preliminary use, e.g. referencing of LADCP profiles.

5.5 Underway data

(A. Bendinger. A. Klein)

The sea surface temperature (SST) and sea surface salinity (SSS) data were obtained by the ship's internal Thermosalinograph (TSG). Maria S. Merian has two TSG systems that enable continuous measurement of sea surface parameters. The two TSGs alternate every 12 hours. Therefore, one TSG is active while the other one is being flushed to prevent biofouling. Both TSGs have a temperature and a conductivity cell. The temperature cell is located at the ship's hull at about 7 m depth and is considered to be the SST.

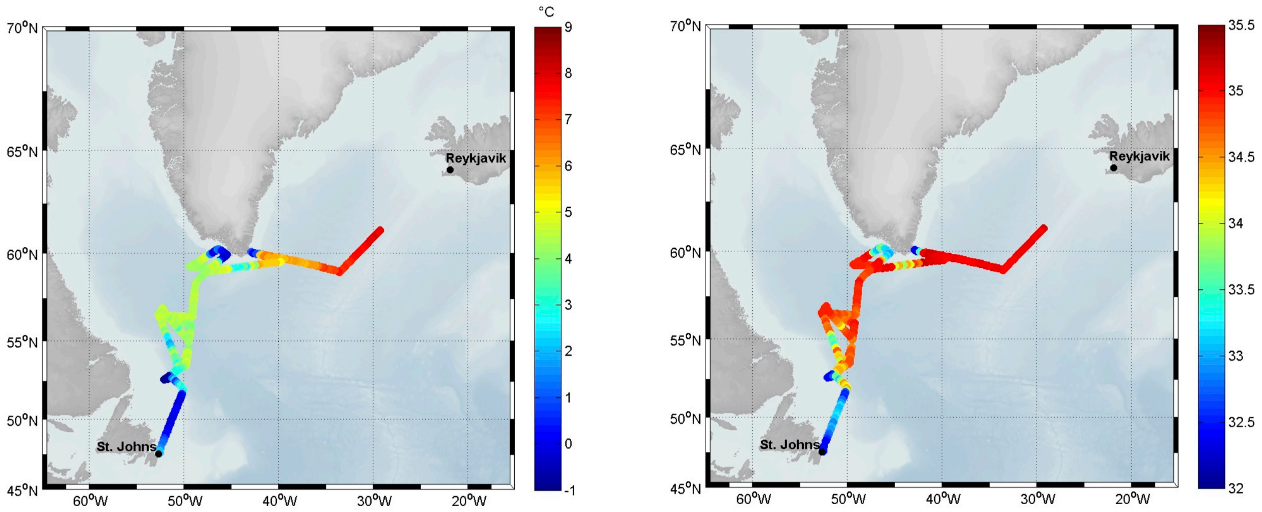


Fig 5.8: (left) Sea surface temperature and (right) sea surface salinity along the cruise track of Maria S Merian cruise MSM54

During the cruise, between May 12th and ending June 3rd, different hydrographic regimes have been crossed (Figure 5.8) with cold and fresher water closer to the coast and warmer (warmest in the northern Irminger Sea) and more saline waters in the open ocean.

During the cruise water samples were taken at least once a day from each of the two Thermosalinograph (TSG) container. At least 24 hours after sampling, the salinity was then determined with the Guildline salinometer (section 5.3.4). The comparison of both salinities is shown in Figure 5.9. The measurement results in a small offset of sensor 1 of +0.001. Sensor 2 shows a greater deviation with +0.0158.

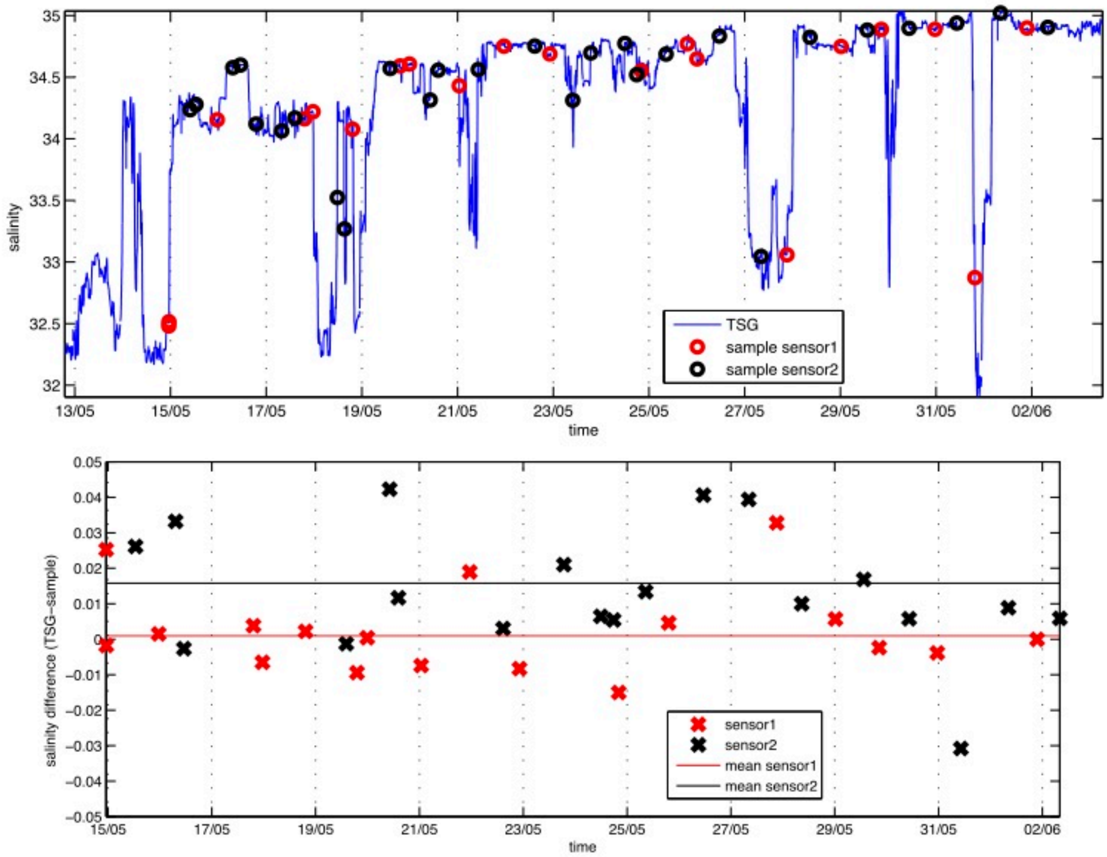


Fig. 5.9: (upper) Salinity along the track merged from the two TSG devices with sample time indicated by circles. (lower) The differences between the two salinities derived from the conductivity sensors in the two TSG and the salinity derived from Salinometer measurements of the samples.

Underway measurement of meteorological parameters

Throughout MSM54 a selection of meteorological variables such as air temperature, air pressure, wind speed and direction, humidity and radiative fluxes were collected. Meteorological parameters were measured by an automatized weather station whose sensors are located between 25 and 29m above sea level. Derived quantities such as radiative fluxes were calculated based on bulk estimation. The net longwave heat flux into the ocean is computed following Dickey et al (1994), sensible and latent heat flux following Fairall et al (1996). The wind speed was corrected from 29m to 10m height following Smith (1988). Otherwise, there was no need for correction considering true wind speed and direction as the weather station automatically evaluates the raw data. On top of that, a weather balloon was launched twice a day by the ship system operator for the German weather service DWD.

The wind direction often changed with varying wind speed between less than 2 m s^{-1} and 18 m s^{-1}. There were cold and relatively strong northwesterly winds around 0°C coming off the coast of New Foundland and Labrador during the first days and strong southwesterly/southerly winds with more than 7 °C during the last couple of days of MSM54 (Figure 5.10).

Between May 12th and June 3rd the air temperature ranged between 0 °C and 9 °C and the water temperature between -1 °C and 8 °C. The highest descent of both, air and water temperature was detected on May 14th, 18th, 27th and 31th when approaching the cold and fresh surface currents called Labrador Current as well as West and East Greenland Current (Figure 5.11).

The air pressure was at its lowest on May 15th with 993 hPa and rose up to 1035 hPa on June 3rd. The minimum humidity was approximately 65%. In the period between May 13th and May 19th the humidity was almost consistently close to 100%, which explains some heavy fog events during the first week of the cruise. Additionally, there was high humidity on the transit to Iceland.

The net longwave heat flux was mostly negative (Figure 5.12), hence upward. Net downward longwave heat flux was recorded during fog and strong cloud cover between May 13th and May 16th as well as around June 2nd with a maximum of 13 W m^{-2}. The latent heat flux, which is nearly coherent with the longwave heat flux, was overall slightly negative and resulted in a cooling of the ocean. Downward flux of both, latent and sensible heat, lead to a warming of the ocean. Enhanced downward sensible heat flux was recorded around May 15th, 25th, 27th and June 1st when air temperature was higher than SST (Figure 5.11). When the water temperature was higher, the sensible heat flux was upward.

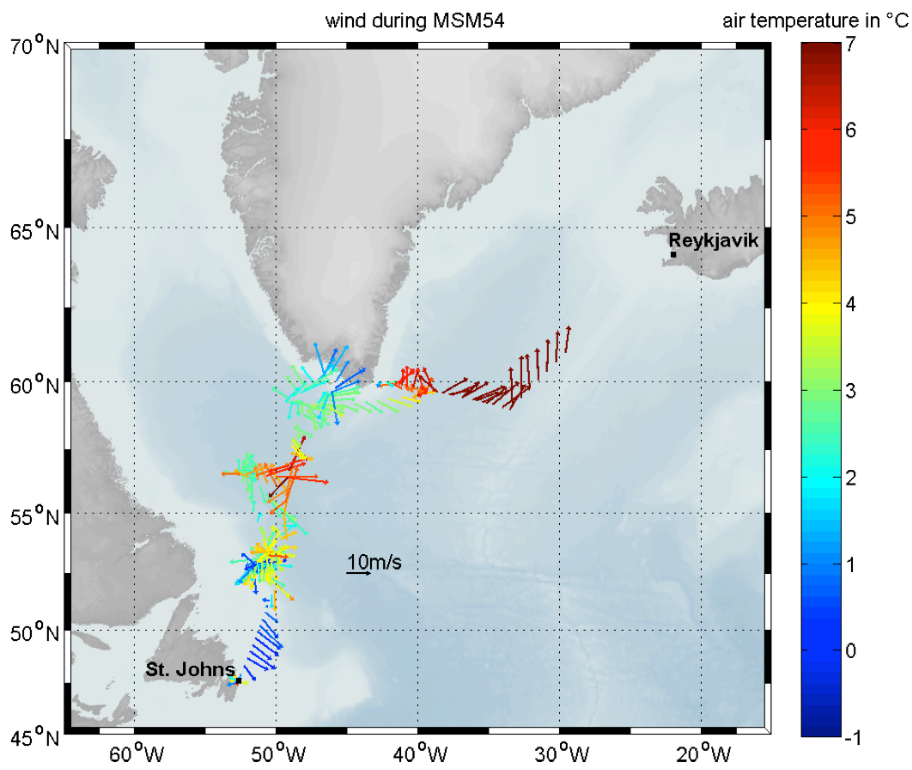


Fig 5.10: Wind vectors along cruise track MSM54 (colour indicate air temperature).

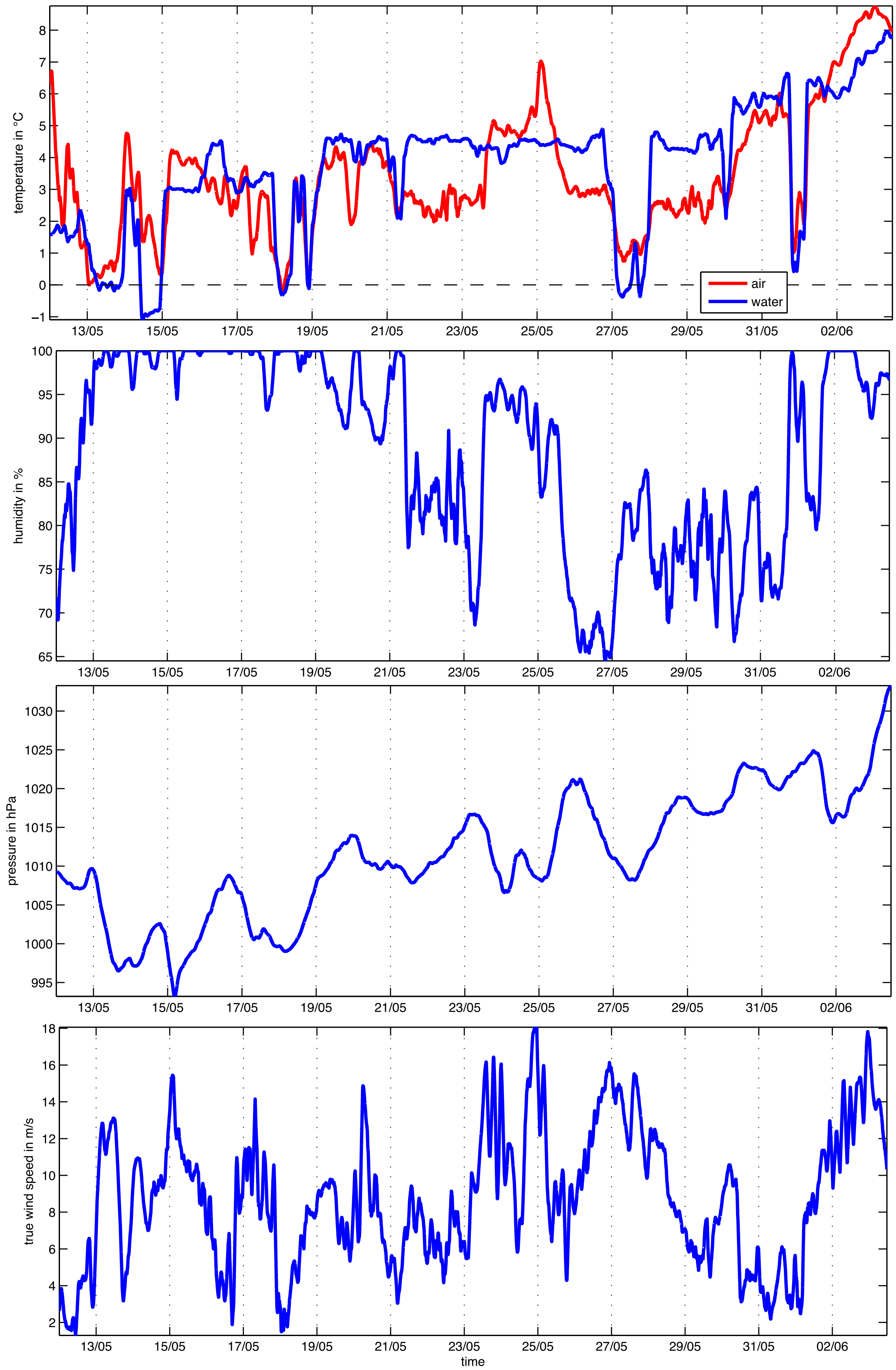


Fig. 5.11: (top to bottom) Surface air (red) and water (blue) temperature, relative humidity (%), air pressure, and wind speed from surface observations during MSM54.

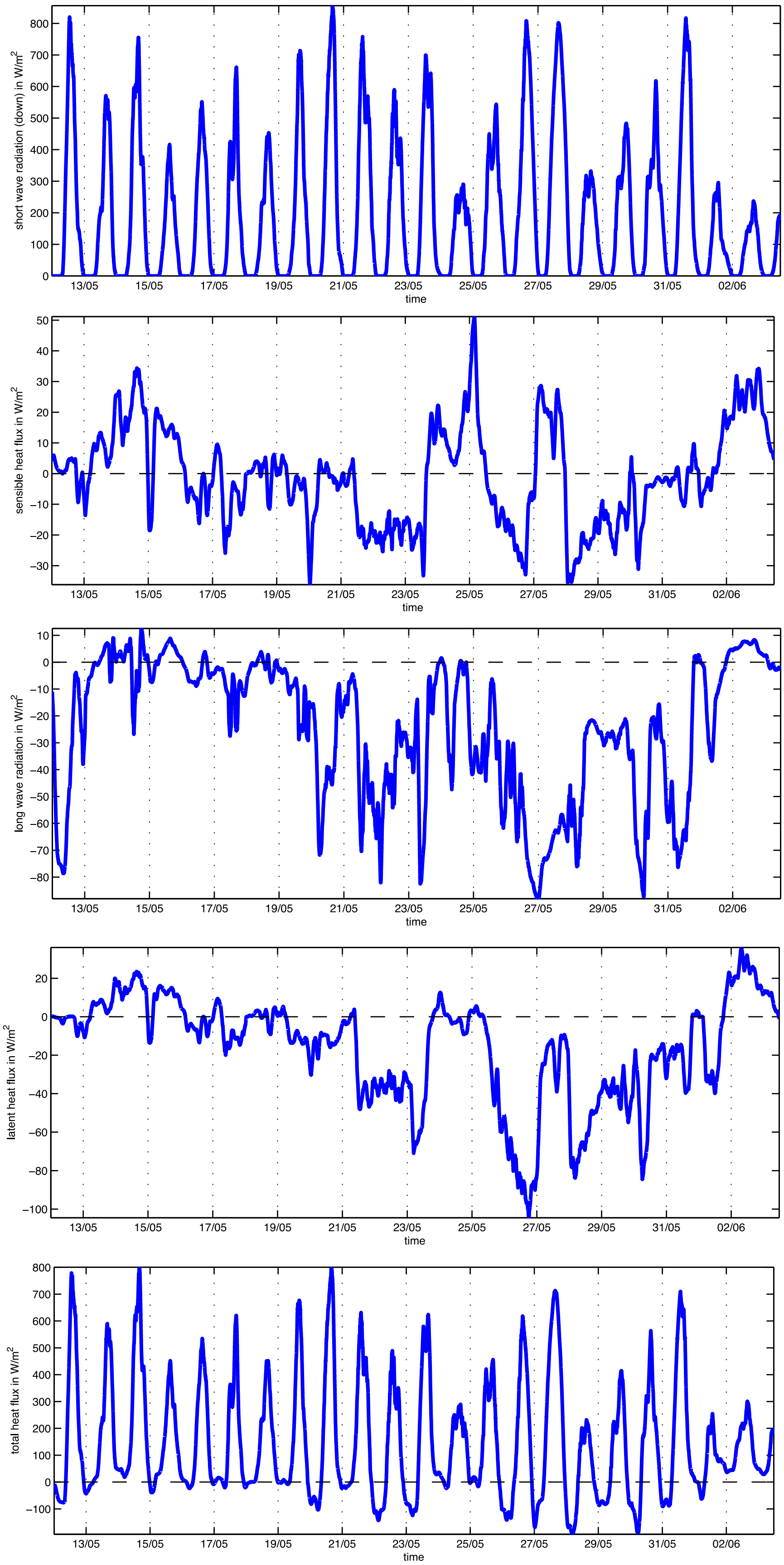


Fig. 5.12: (top to bottom) Shortwave, sensible, net long-wave, latent, and total (sum) heat flux observed and calculated from surface observations and parametrizations (Fairell et al. 1996).

6 Station List RV MARIA S. MERIAN MSM54

Gear coding

CTD/RO: CTD/lowered Acoustic Doppler Current Profiler/and rosette sampler

MOOR: Mooring operation (code: Re - recovery; De - deployment)

Ship Station#	CTD# /moor code	Gear code	Date dd/mm/yyyy	Time	Latitude [N]	Longitude [W]	Depth [m]
MSM54/0301-1	1	CTD/RO	12/05/2016	19:32	47° 32.78' N	52° 35.21' W	175.6
MSM54/0302-1	2	CTD/RO	14/05/2016	13:05	52° 37.14' N	52° 03.50' W	299.6
MSM54/0303-1	3 technical probl.	CTD/RO	14/05/2016	16:19	52° 45.41' N	51° 42.35' W	516.4
MSM54/0303-2	4	CTD/RO	14/05/2016	21:07	52° 45.39' N	51° 42.44' W	512.8
MSM54/0304-1	5	CTD/RO	14/05/2016	22:29	52° 47.59' N	51° 36.52' W	993.9
MSM54/0305-1	6	CTD/RO	15/05/2016	00:17	52° 50.22' N	51° 29.35' W	1469.9
MSM54/0306-1	7	CTD/RO	15/05/2016	02:37	52° 52.74' N	51° 22.97' W	1999.7
MSM54/0307-1	8	CTD/RO	15/05/2016	06:46	52° 59.22' N	51° 08.28' W	2414.9
MSM54/0308-1	9	CTD/RO	15/05/2016	12:04	53° 05.17' N	50° 52.18' W	2888
MSM54/0309-1	Re K9	MOOR	15/05/2016	16:18	53° 07.13' N	50° 51.69' W	2914
MSM54/0310-1	10	CTD/RO	15/05/2016	22:00	53° 11.69' N	50° 37.64' W	3138.6
MSM54/0311-1	11	CTD/RO	16/05/2016	01:51	53° 17.85' N	50° 22.37' W	3303.7
MSM54/0312-1	12	CTD/RO	16/05/2016	05:39	53° 24.00' N	50° 07.38' W	3472.1
MSM54/0313-1	13	CTD/RO	16/05/2016	09:41	53° 32.48' N	49° 45.20' W	3590
MSM54/0314-1	Re DSOW5	MOOR	16/05/2016	12:33	53° 35.78' N	49° 46.90' W	3590
MSM54/0315-1	Re DSOW2	MOOR	16/05/2016	16:34	53° 15.07' N	50° 33.42' W	3155
MSM54/0316-1	Re DSOW1	MOOR	16/05/2016	21:29	53° 02.10' N	51° 04.79' W	2566
MSM54/0317-1	14	CTD/RO	16/05/2016	23:18	53° 02.82' N	51° 00.00' W	2720.9
MSM54/0318-1	15	CTD/RO	17/05/2016	02:29	53° 08.74' N	50° 45.21' W	3024.9
MSM54/0319-1	16	CTD/RO	17/05/2016	05:34	53° 15.29' N	50° 30.10' W	3184.8
MSM54/0320-1	De DSOW1	MOOR	17/05/2016	12:13	53° 02.796´N	51° 04.804´W	2700
MSM54/0321-1	De K9	MOOR	17/05/2016	18:59	53° 08.221'N	50° 52.253'W	2900
MSM54/0322-1	17	CTD/RO	17/05/2016	21:56	52° 56.53' N	51° 16.02' W	2313.7
MSM54/0323-1	18	CTD/RO	18/05/2016	00:49	52° 52.92' N	51° 23.19' W	1996.7
MSM54/0324-1	19	CTD/RO	18/05/2016	02:42	52° 50.41' N	51° 29.39' W	1461.2
MSM54/0325-1	20	CTD/RO	18/05/2016	04:09	52° 47.70' N	51° 36.47' W	1003.7
MSM54/0326-1	21	CTD/RO	18/05/2016	05:27	52° 45.49' N	51° 42.36' W	518
MSM54/0327-1	Re K7	MOOR	18/05/2016	09:17	52° 51.45' N	51° 28.96' W	1635
MSM54/0328-1	Re K8	MOOR	18/05/2016	12:38	52° 56.82' N	51° 17.90' W	2230
MSM54/0329-1	De K8	MOOR	18/05/2016	19:05	52° 57.339'N	51°18.606'W	2230
MSM54/0330-1	De K7	MOOR	18/05/2016	22:30	52°50.418´N	51°32.899´W	1420
MSM54/0331-1	22	CTD/RO	19/05/2016	00:10	52° 53.04' N	51° 23.59' W	1972.9
MSM54/0332-1	Re K10	MOOR	19/05/2016	10:48	53° 22.35' N	50° 15.30' W	3385
MSM54/0333-1	23	CTD/RO	19/05/2016	15:59	53° 33.67' N	49° 44.56' W	3606.2
MSM54/0334-1	De DSOW5	MOOR	19/05/2016	18:12	53° 35.522' N	49° 46.905' W	3600
MSM54/0335-1	24	CTD/RO	19/05/2016	21:44	54° 01.36' N	49° 39.23' W	3646.6
MSM54/0336-1	25	CTD/RO	20/05/2016	03:08	54° 30.18' N	49° 33.39' W	3618.4
MSM54/0337-1	De K10	MOOR	20/05/2016	13:35	53° 23.245'N	50° 15.285'W	3380
MSM54/0338-1	De DSOW2	MOOR	20/05/2016	19:50	53° 15.399'N	50° 33.267'W	3200

MSM54/0339-1	26	CTD/RO	20/05/2016	21:35	53° 17.43' N	50° 29.50' W	3232.6
MSM54/0340-1	Re K1	MOOR	21/05/2016	17:03	56° 33.74' N	52° 39.37' W	3495
MSM54/0341-1	27	CTD/RO	21/05/2016	21:10	56° 35.43' N	52° 38.24' W	3495.6
MSM54/0342-1	28	CTD/RO	22/05/2016	01:00	56° 44.80' N	52° 27.46' W	3513.9
MSM54/0343-1	29	CTD/RO	22/05/2016	04:46	56° 56.79' N	52° 14.48' W	3516.9
MSM54/0344-1	De SeaCycler	MOOR	22/05/2016	09:40	56° 49.15' N	52° 12.57' W	3533
MSM54/0345-1	De K1	MOOR	22/05/2016	17:13	56°33.702'N	52°39.421'W	3519.3
MSM54/0346-1	30	CTD/RO	23/05/2016	02:33	56° 48.96' N	52° 14.15' W	3525.6
MSM54/0347-1	31	CTD/RO	23/05/2016	16:40	54° 59.07' N	49° 27.12' W	3646
MSM54/0348-1	32	CTD/RO	23/05/2016	21:28	55° 27.94' N	49° 22.24' W	3670.4
MSM54/0349-1	33	CTD/RO	24/05/2016	02:24	55° 56.44' N	49° 14.61' W	3768.5
MSM54/0350-1	exchange head buoy	MOOR	24/05/2016	14:16	56° 33.702'N	52° 39.421'W	3533
MSM54/0351-1	34	CTD/RO	25/05/2016	01:34	56° 25.64' N	49° 08.76' W	3678.4
MSM54/0352-1	35	CTD/RO	25/05/2016	06:21	56° 54.21' N	49° 03.13' W	3632.5
MSM54/0353-1	36	CTD/RO	25/05/2016	11:15	57° 22.95' N	48° 58.63' W	3571.1
MSM54/0354-1	37	CTD/RO	25/05/2016	16:26	57° 52.02' N	48° 52.13' W	3486.4
MSM54/0355-1	38	CTD/RO	25/05/2016	21:18	58° 20.87' N	48° 46.22' W	3484
MSM54/0356-1	39	CTD/RO	26/05/2016	03:09	58° 46.93' N	48° 04.08' W	3312.3
MSM54/0357-1	40	CTD/RO	26/05/2016	06:43	58° 56.78' N	47° 42.17' W	2887.6
MSM54/0358-1	41	CTD/RO	26/05/2016	10:01	59° 06.38' N	47° 20.13' W	2935.4
MSM54/0359-1	42	CTD/RO	26/05/2016	12:59	59° 12.58' N	47° 06.03' W	2936.7
MSM54/0360-1	43	CTD/RO	26/05/2016	15:46	59° 18.45' N	46° 52.07' W	2460.5
MSM54/0361-1	44	CTD/RO	26/05/2016	18:02	59° 22.75' N	46° 41.44' W	2140.2
MSM54/0362-1	45	CTD/RO	26/05/2016	20:21	59° 27.00' N	46° 32.07' W	2022.3
MSM54/0363-1	46	CTD/RO	26/05/2016	22:27	59° 29.87' N	46° 26.30' W	2168.1
MSM54/0364-1	47	CTD/RO	27/05/2016	00:49	59° 32.00' N	46° 22.36' W	1774.5
MSM54/0365-1	48	CTD/RO	27/05/2016	02:38	59° 33.87' N	46° 17.21' W	1304.6
MSM54/0366-1	49	CTD/RO	27/05/2016	04:11	59° 36.27' N	46° 11.33' W	885.1
MSM54/0367-1	50	CTD/RO	27/05/2016	05:23	59° 38.12' N	46° 06.74' W	606.6
MSM54/0368-1	51	CTD/RO	27/05/2016	06:42	59° 40.88' N	45° 59.54' W	199.3
MSM54/0369-1	52	CTD/RO	27/05/2016	07:52	59° 44.85' N	45° 50.17' W	159.8
MSM54/0370-1	53	CTD/RO	27/05/2016	08:54	59° 48.32' N	45° 41.83' W	142.4
MSM54/0371-1	54	CTD/RO	27/05/2016	09:53	59° 51.88' N	45° 33.49' W	127.2
MSM54/0372-1	55	CTD/RO	27/05/2016	10:46	59° 54.25' N	45° 28.04' W	141.6
MSM54/0373-1	56	CTD/RO	27/05/2016	14:28	60° 13.00' N	46° 19.52' W	115.6
MSM54/0374-1	57	CTD/RO	27/05/2016	15:31	60° 10.47' N	46° 28.39' W	120.3
MSM54/0375-1	58	CTD/RO	27/05/2016	16:27	60° 08.81' N	46° 33.63' W	832.8
MSM54/0376-1	59	CTD/RO	27/05/2016	17:53	60° 06.54' N	46° 42.06' W	1256.2
MSM54/0377-1	60	CTD/RO	27/05/2016	19:58	60° 01.99' N	46° 55.53' W	1947.8
MSM54/0378-1	61	CTD/RO	27/05/2016	22:17	59° 56.73' N	47° 09.81' W	2605.4
MSM54/0379-1	62	CTD/RO	28/05/2016	01:21	59° 52.62' N	47° 26.30' W	2834.2
MSM54/0380-1	63	CTD/RO	28/05/2016	04:22	59° 47.57' N	47° 43.00' W	2825
MSM54/0381-1	64	CTD/RO	28/05/2016	07:18	59° 41.79' N	47° 59.87' W	3035.9
MSM54/0382-1	65	CTD/RO	28/05/2016	10:43	59° 34.84' N	48° 20.41' W	3195.8
MSM54/0383-1	66	CTD/RO	28/05/2016	14:11	59° 26.99' N	48° 48.16' W	3302.7

MSM54/0384-1	67	CTD/RO	28/05/2016	18:07	59° 16.00' N	49° 21.54' W	3398.7
MSM54/0385-1	Re DSOW4	MOOR	29/05/2016	10:48	59° 13.00' N	47° 04.86' W	2938
MSM54/0386-1	De DSOW4	MOOR	29/05/2016	12:48	59° 12.93´N	47° 04.91´W	2940
MSM54/0387-1	Re DSOW3	MOOR	29/05/2016	15:13	59° 00.26' N	47° 33.92' W	3112
MSM54/0388-1	De DSOW3	MOOR	29/05/2016	16:57	59° 00.43´N	47° 33.87´W	3107
MSM54/0389-1	Re CIS13	MOOR	30/05/2016	11:35	59° 30.80' N	39° 47.39' W	2948
MSM54/0390-1	68	CTD/RO	30/05/2016	15:25	59° 31.07' N	39° 49.73' W	2933.1
MSM54/0391-1	De CIS14	MOOR	30/05/2016	20:57	59° 31.826'N	39°46.982'W	2904
MSM54/0392-1	69	CTD/RO	31/05/2016	01:23	59° 40.79' N	39° 18.31' W	2848.5
MSM54/0393-1	70	CTD/RO	31/05/2016	04:39	59° 42.81' N	39° 49.62' W	2742.4
MSM54/0394-1	71	CTD/RO	31/05/2016	07:45	59° 46.88' N	40° 20.98' W	2573
MSM54/0395-1	hieve CIS14	MOOR	31/05/2016	10:42	59° 31.826'N	39°46.982'W	2904
MSM54/0396-1	72	CTD/RO	31/05/2016	21:06	60° 03.09' N	42° 52.18' W	176.9
MSM54/0397-1	73	CTD/RO	31/05/2016	22:18	59° 59.98' N	42° 39.85' W	194.1
MSM54/0398-1	74	CTD/RO	31/05/2016	23:39	59° 58.60' N	42° 22.29' W	206.9
MSM54/0399-1	75	CTD/RO	01/06/2016	00:42	59° 57.40' N	42° 09.94' W	496.5
MSM54/0400-1	76	CTD/RO	01/06/2016	01:32	59° 57.24' N	42° 08.10' W	829
MSM54/0401-1	77	CTD/RO	01/06/2016	02:51	59° 56.82' N	42° 05.59' W	1463.1
MSM54/0402-1	78	CTD/RO	01/06/2016	04:59	59° 54.68' N	41° 45.54' W	1815.1
MSM54/0403-1	79	CTD/RO	01/06/2016	07:12	59° 53.18' N	41° 25.59' W	1901.4
MSM54/0404-1	80	CTD/RO	01/06/2016	09:30	59° 51.25' N	41° 05.95' W	2090.1
MSM54/0405-1	81	CTD/RO	01/06/2016	12:02	59° 49.35' N	40° 46.40' W	2562.8
MSM54/0406-1	82	CTD/RO	01/06/2016	19:42	59° 36.49' N	38° 35.07' W	2988.3
MSM54/0407-1	83	CTD/RO	02/06/2016	00:21	59° 32.02' N	37° 48.04' W	3128.7
MSM54/0408-1	84	CTD/RO	02/06/2016	05:00	59° 25.01' N	36° 52.03' W	3105.5
MSM54/0409-1	85	CTD/RO	02/06/2016	09:38	59° 18.87' N	35° 55.23' W	3096.9
MSM54/0410-1	86	CTD/RO	02/06/2016	13:48	59° 12.81' N	35° 10.08' W	3012.3
MSM54/0411-1	87	CTD/RO	02/06/2016	20:25	58° 59.00' N	33° 30.40' W	2523.1

7 Data and Sample Storage and Availability

(GEOMAR Data management: datamanagement@geomar.de)

In Kiel a joint Datamanagement-Team is active, which stores the data in a web based multiuser-system. In a first phase the data are only available to the user groups (e.g. NACLIM group via the NACLIM website; OSNAP via OSNAP website). After a three year proprietary time these data will be made public by distributing them to national and international data archives through the GEOMAR data management team, i.e. the data will be submitted to PANGAEA. When the data sets will be archived in the PANGAEA Open Access library digital object identifiers (DOIs) will be assigned. A kml link can be found at https://portal.geomar.de/metadata/leg/ kmlexport/ 337574.

Type	**Available (internal GEOMAR)**	**Free Access (PANGAEA)**	**Contact**
CTD O_2 data	08/2016	08/2019	jkarstensen@geomar.de

vmADCP data	08/2016	08/2019	jkarstensen@geomar.de
Mooring data	08/2016	08/2019	jkarstensen@geomar.de
lADCP data	08/2016	08/2019	jkarstensen@geomar.de
TSG data	08/2016	08/2019	jkarstensen@geomar.de
Underway data	08/2016	08/2019	jkarstensen@geomar.de

8 Acknowledgements

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10 Appendix

10.1. Configuration of recovered moorings: 53°N Array

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_ 1111/ K7, Labrador Sea Compiled: date/initial last up-date: 2.06.16, MO
Mooring design: C. Begler

Deployment
Date: 09.08.2014 Time: 10:09-12:30 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 52°51.939 Longitude: 051°28.910 Time: 12:30 UTC
Expected position Latitude: 52°51.935 Longitude: 051°28.717
Water depth (corrected): 1715.7 m

Recovery
Date: 18.05.2016 Time: 9:24-10:56 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
42 m	Argos	5467			XIOS
46 m	MCP-SM	3505	CTD07/08.08	CTD46, 26.05.	BIO, P2000, full record
199 m	MCP-SM	3507	CTD07/08.08	CTD46, 26.05.	BIO, P1000, full record
399 m	LR-ADCP, FL45''				BIO, full record
405 m	MC-SM	2614	CTD07/08.08	CTD27, 21.05.	Full record
578 m	RCM-8	5573			AVT_L_R, full record
580 m	MCP-SM	3503	CTD07/08.08	CTD46,	P2000, full record
869 m	RCM-8	11576			AVT_L_R, full record
871 m	MCP-SM	10691		CTD25, 20.05.	P7000, full record
1160 m	RCM-8	4998			AVT_L_R, partial record
1161 m	MC-SM	10633		CTD25,	P7000, full record
1450 m	RCM-8	11617			AVT_L_R, full record
1452 m	MCP-SM	10704		CTD25, 20.05.	P7000, full record
1474 m	AR 661 AR 861	350 1649			

Comment: 150m of ¼" ins wire were added between releaser and anchor as depth increased

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1112 / K8, Labrador Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 09.08.2014 Time: 19:35-22:55 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch	Latitude: 52°57.174	Longitude: 051°17.468	Time: 22:55
Expected position	Latitude: 52°56.461	Longitude: 051°18.956	
Water depth (corrected):	2222.5 m		

Recovery
Date: 18.05.2016 Time: 12:42-14:08 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
45 m	Argos	667			
48 m	MC #1	10700		CTD25, 20.05.	T,C,P, full record
103 m	MC#2	10632		CTD25, 20.05.	T,C,P, full record
104 m	Aquadopp	P26209-30			Full record
199 m	Aquadopp	P26209-37			Full record
595 m	MC #3	10703		CTD25,	T,C,P, full record
596 m	Aquadopp	P26209-31			Full record
1002 m	Aquadopp	P26209-22			Full record
1499 m	MC #4	1287	CTD07,08.08.	CTD26, 20.05.	T,C, full record
1500 m	Aquadopp	P26209-32			Full record
1895 m	MC #5	1322	CTD07,08.08.	CTD26,	T,C, full record
1897 m	Aquadopp	P26209-29			Full record
2152 m	MC #6	10634		CTD25, 20.05.	T,C,P, full record
2153 m	Aquadopp	P26209-23			Full record
2174 m	AR 661 AR861	52 1647			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1113/ DSOW1, Labrador Sea Compiled: last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 08. August 2014 Time: 17:35-18:20 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 53°02.763 Longitude: 051°04.843 Time: 18:20 UTC

Expected position Latitude: 53°02.764 Longitude: 051°04.801
Water depth (corrected): 2620.2 m

Recovery
Date: 16.05.2016 Time: 21:22-21:30 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
2406	Microcat T,C,P	10636	-	CTD26, 20.05.	P7000, full record
2407	Aquadopp	26209-26			Full record
2552	RCM-8	9344			Full record
2553	Microcat T,C,P	10699	-	CTD27, 21.05.	P7000, full record
2575	AR 661	838			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1114 / K9, Labrador Sea Compiled: date/initial last up-date: 06.11.16, MO
Mooring design: C. Begler

Deployment
Date: 11.08.2014 Time: 11:29-14:38 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 53°08.522 Longitude: 050°52.008 Time: 14:38
Expected position Latitude: 53°07.842 Longitude: 050°52.526
Water depth (corrected): 2916.3 m

Recovery
Date: 15.05.2016 Time: 16:51-19:22 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
99 m	watchdog	5511			
101 m	MC #1 T,C,P	10690		CTD17, 17.05.	Full record
202 m	Aquadopp	P26209-25			Full record
593 m	RCM-8	11442			Partial record
603 m	MC #2 T,C,P	0925	CTD13,11.08.	CTD17, 17.05.	Full record
999 m	RCM-8	9833			Full record
1496 m	MC #3 T,C	0936	CTD13,11.08.	CTD17,	Full record
1507 m	Aquadopp	P26209-4			Full record
2004 m	Aquadopp	P26209-8			Full record
2409 m	RCM-8	9345			Full record
2410 m	MC #4 T,C,P	10708		CTD17,	Full record
2704 m	MC #5 T,C,P	10637		CTD17,	Full record
2705 m	Aquadopp	P26209-10			Full record
2801 m	MC #6 T,C	1317	CTD13,11.08.	CTD17, 17.05.	Full record
2802 m	Aquadopp	P26209-35			Full record
2824 m	AR 861 RT 661	1646 107			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_ 1115 / DSOW2, Labrador Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 11.08.2014 Time: 22:07-01:00 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 53°15.002 Longitude: 050°33.053 Time: 01:00
Expected position Latitude: 53°15.497 Longitude: 050°32.755
Water depth (corrected): 3179.1 m

Recovery
Date: 16.05.2016 Time: 16:45-18:38 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
91 m	watchdog	7848			
94 m	MC #1 T,C,P	10689		CTD26, 20.05.	Full record
1338 m	M-CTD				Partial record
2731 m	RCM-8	10815			Full record
2742 m	MC #2 T,C	942	CTD13,11.08.	CTD26, 20.05.	
2939 m	ADCP-up	14909			150kHz, Titanium Frame,
2954 m	MC #3 T,C	1323	CTD13,11.08.	CTD26,	Full record
3100 m	RCM-8	9322			Full record
3101 m	MC #4 T,C,P	10635		CTD26, 20.05.	Full record
3124 m	RT 661 AR661	173 351			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1116 / K10, Labrador Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 12.08.2014 Time: 14:47-18:04 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 53°22.372 Longitude: 050°15.185 Time: 18:04
Expected position Latitude: 53°23.244 Longitude: 050°15.282
Water depth (corrected): 3380.8 m

Recovery
Date: 19.05.2016 Time: 10:55-13:15 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
101 m	Watchdog	2268			
104 m	MC #1 T,C,P	10706	CTD15,12.08.	CTD25, 20.05.	Full record
209 m	MC #2 T,C	1316	CTD15,12.08.	CTD38, 25.05.	Full record
210 m	Aquadopp	P26209-5			Full record
401 m	MC #3 T,C,P	10678	CTD15,12.08.	CTD27, 21.05.	Full record
606 m	MC #4 T,C	937	CTD15,12.08.	CTD46,	Full record
607 m	Aquadopp	P26209-7			Full record
1002 m	MC #5 T,C,P	10681	CTD15,12.08.	CTD27,	Full record
1255 m	MC #6 T,C,P	2262	CTD15,12.08.	CTD27, 21.05.	Full record
1510 m	Argonaut	D299			Partial record
1511 m	MC #7 T,C	1321	CTD07,08.08.	CTD27,	Full record
1763 m	MC #8 T,C,P	10680	CTD15,12.08.	CTD27,	Full record
2009 m	Argonaut	D188			Full record
2425 m	MC #9 T,C,P	2718	CTD15,12.08.	CTD27, 21.05.	Full record
2802 m	MC #10 T,C	946	CTD15,12.08.	CTD27, 21.05.	Full record
2803 m	Aquadopp	P26209-12			Full record
3056 m	MC #11 T,C,P	3757	CTD15,12.08.	CTD27, 21.05.	Full record
3262 m	MC #12 T,C	940	CTD15,12.08.	CTD38, 25.05.	Full record
3263 m	Aquadopp	P24543-2			Full record
3274	AR 661 AR661	821 191			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1133 / DSOW5, Labrador Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 12.08.2014 Time: 10:17-10:53 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch	Latitude: 53°35.581	Longitude: 049°46.834	Time: 10:53
Expected position	Latitude: 53°35.510	Longitude: 049°46.889	
Water depth (corrected):	3614.8 m		

Recovery
Date: 16.05.2016 Time: 12:39-12:59 Cruise: MSM 54
PI on-board: Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
3137 m	Watchdog	11458			
3153 m	RCM-8	9726			Partial record
3154 m	MC #1 T,C,P	10707	CTD15,12.08.	CTD26, 20.05.	Full record
3552 m	RCM-8	10501			Full record
3563 m	MC #2 T,C	10679		CTD27, 21.05.	Full record
3575 m	AR661	428			

10.2. Configuration of recovered moorings: WHOI array

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1122/ DSOW 3, Labrador See Compiled: date, initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 24.08.2014 Time: Cruise: Knorr
Mooring PI on-board:

Anchor launch Latitude: Longitude: Time:
Expected position Latitude: 59°0.46'N Longitude: 47°33.87'W
Water depth (corrected): 3104 m

Recovery
Date: 29.05.2016 Time: 15:17-15:36 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
2450	Microcat T,C,P	10697		CTD68, 30.05.	P7000, full record
2450	Aquadopp	P26209-3			Full record
2955	Microcat T,C,P	10705		CTD68, 30.05.	P7000, full record
2955	Aquadopp	P26209-6			Full record

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1123/ DSOW 4, Labrador See Compiled: date, initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 24.08.2014 Time: 13:42 Cruise: Knorr
Mooring PI on-board:

Anchor launch Latitude: Longitude: Time:
Expected position Latitude: 59°12.93'N Longitude: 47°4.91'W
Water depth (corrected): 2941 m

Recovery
Date: 29.05.2016 Time: 10:55-11:18 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
2050	Microcat T,C,P	10692		CTD68, 30.05.	P7000, full record
2050	Aquadopp	P26209-1			Full record
2555	Microcat T,C,P	10698		CTD68, 30.05.	P7000, full record
2555	Aquadopp	P26209-9			Full record

10.3. Configuration of recovered moorings: Deep convection regions (K1, CIS)

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1117 / K1, Labrador Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 13.08.2014 Time: 20:07-00:00 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 56°33.536 Longitude: 052°39.483 Time: 00:00
Expected position Latitude: 56°35.448 Longitude: 052°38.244
Water depth (corrected): 3510.6 m

Recovery
Date: 21.05.2016 Time: 17:08-19:08 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
-335 m	Develogic Iridium Float				EMEI 300234060272690
-323 m	Eco Triplet	1199			
-323 m	MCP-IM pump	37-12152			?
51 m	Develogic Seaguard; optode, C,P	001			Modelno. DCS4830
100 m	MC-IM pump ODO	12151			Partial record
300 m	MCP-IM	10654		CTD38,	P1000
501 m	MC-IM	10659		CTD38,	Full record
751 m	MC-IM	10655		CTD38,	Full record
751 m	Aquadopp DW, TP,U,V,W	P26209-11			Down, full record
902 m	MC-IM	10658		CTD38, 25.05.	Full record
1151 m	MCP-IM	10656		CTD38, 25.05.	Full record
1154 m	Watchdog	12621			(integrated in Benthos)
1297 m	MC-SM	10657		CTD38,	Full record
1496 m	MCP-SM	10639		CTD38, 25.05.	P3500
1504 m	RCM-8	10500			AVT_L_R, partial record
1806 m	MCP-SM	10638		CTD38, 25.05.	P3500
3436 m	MCP-SM	10651		CTD38, 25.05.	P7000
3466 m	AR661 AR861	441 435			

GEOMAR, FB1: Physical Oceanography: Mooring metadata

KPO_1124 / CIS, Irminger Sea Compiled: date/initial last up-date: 06.11.2016, MO
Mooring design: C. Begler

Deployment
Date: 18.08.2014 Time: 18:08- 21:56 Cruise: MSM 40
Mooring PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Anchor launch Latitude: 59°31.827 Longitude: 039°47.029 Time: 00:00
Expected position Latitude: 59°30.645 Longitude: 039°47.239
Water depth (corrected): 2928 m

Recovery
Date: 30.05.2016 Time: 12:30-14:03 Cruise: MSM 54
PI on-board: J. Karstensen, GEOMAR, Kiel, Germany

Instrument			Calibration (CTD cast #, date)		
Depth nom.	Type & Sensors	S/N	Pre-deployment	Post-deployment	Remarks
-244m	Develogic Iridium Float				EMEI 300324060275690
-232 m	MCP-IM pump	10652		CTD82, 1.06.	Full record
-217 m	MC-IM	2252		CTD82, 1.06.	Full record
39 m	MCP-IM	2271		CTD82, 1.06.	Full record
88 m	MC-IM	959		CTD82, 1.06.	Full record
149 m	WH-ADCP	2379			Full record
229 m	MC-IM	2261			Full record
309 m	MC-IM	953		CTD82, 1.06.	Full record
389 m	MC-IM	10650		CTD82, 1.06.	Full record
469 m	MCP-IM	954		CTD82, 1.06.	Full record
549 m	MC-IM	7416		CTD82, 1.06.	Full record
629 m	MC-IM	949		CTD82, 1.06.	Full record
740 m	MCP-IM	2716		CTD82, 1.06.	Full record
870 m	MC-IM	1720		CTD82, 1.06.	Full record
1000 m	Aquadopp DW, T,P,U,V,W	24543-1			Full record
1249 m	MC-IM	950		CTD82, 1.06.	Full record
1499 m	MC-IM	1723		CTD82, 1.06.	Full record
2953 m	RCM-8	9820			Partial record
2954 m	MCP-SM	3416		CTD82, 1.06.	Full record
3466 m	AR661 AR861	441 435			